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JOURNAL

OF THE

NEW-YORK
MICROSCOPICAL SOCIETY

VOLUME X.

INC. 1877.

NEW-YORK:
PUBLISHED FOR THE SOCIETY,
QUARTERLY.

Vol. X. **JANUARY, 1894.** **No. 1.**

10,412

JOURNAL

OF THE

New-York Microscopical Society

EDITED BY

REV. J. L. ZABRISKIE,

WAVERLEY AVE., FLATBUSH, L. I., N. Y.

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INC. 1877

New York:

PUBLISHED FOR THE SOCIETY,

QUARTERLY.

PRESS OF STETTINER, LAMBERT & CO.,
22, 24 & 26 READE STREET.
1894.

[Entered at the Post-Office at New York as second-class matter.]

New-York Microscopical Society.

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JOURNAL

—OF THE—

NEW-YORK MICROSCOPICAL SOCIETY

CONTAINING ITS TRANSACTIONS AND PROCEEDINGS.

PUBLISHED QUARTERLY.

All communications for the JOURNAL, all subscriptions, and all exchanges, should be addressed to the editor, Rev. J. L. Zabriskie, Waverley Avenue, Flatbush, L. I., N. Y.

Terms of Subscription:—In the United States and Canada, One Dollar per annum, beginning with the January number. In Great Britain and Europe, Five Shillings per annum.

W. P. Collins, 157 Great Portland St., London, England, agent for Great Britain.

F. W. DEVOE & CO.,

(ESTABLISHED IN 1852.)

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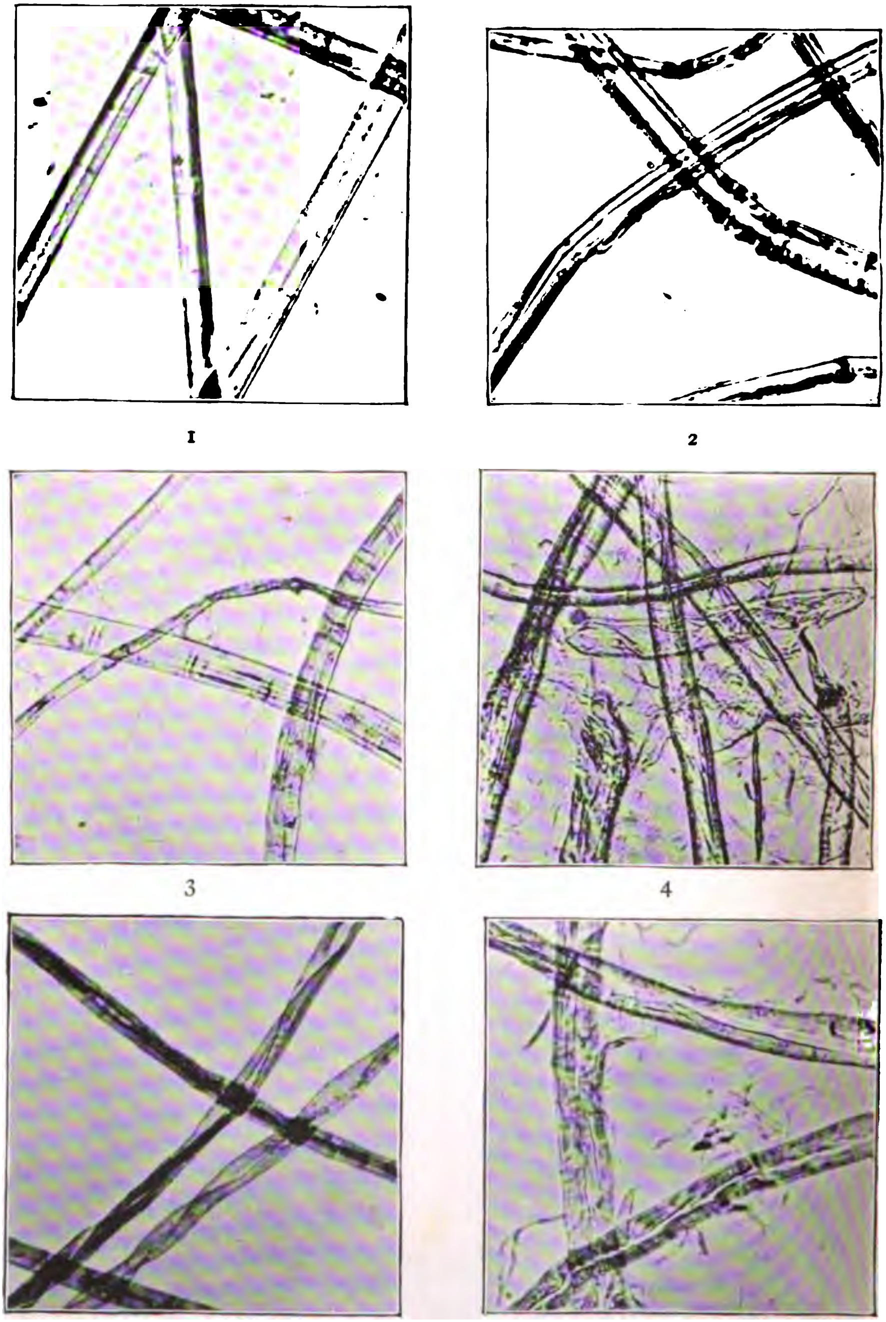
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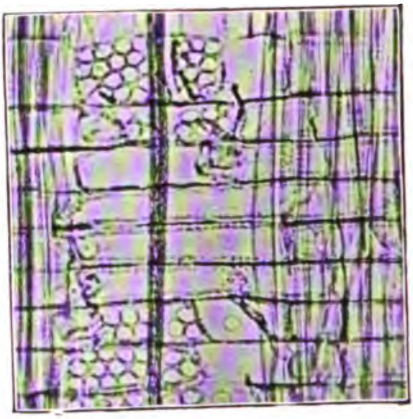

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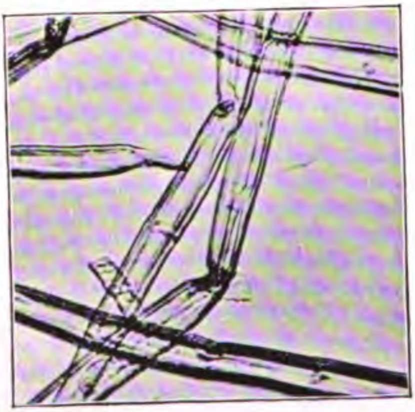

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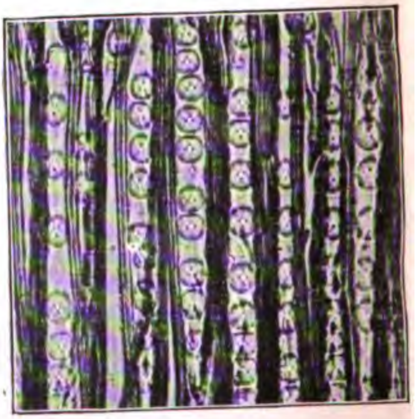

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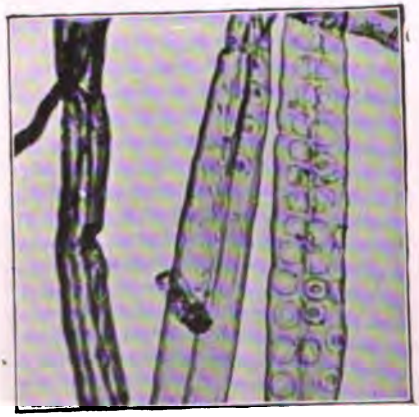

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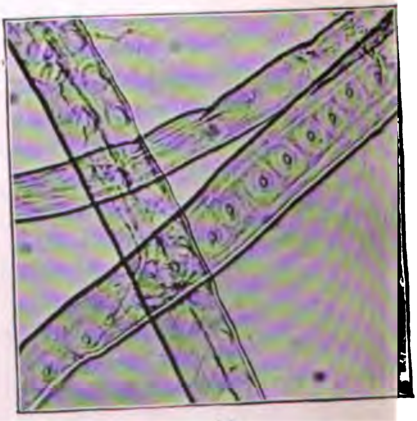

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PAPER FIBRES.

JOURNAL

OF THE

NEW-YORK MICROSCOPICAL SOCIETY.

VOL. X. APRIL, 1894. No. 2.

A MICROSCOPICAL AND CHEMICAL EXAMINATION OF THE ADMIXTURES AND ADULTERATIONS IN PAPERS USED FOR WRITING AND ENGRAVING.

ANNUAL ADDRESS BY THE PRESIDENT, CHARLES S. SHULTZ.

(*Delivered January 5th, 1894.*)

In my brief inaugural before the Society last January I spoke of the importance of the microscope as a means of detecting adulterations in food products, fabrics, etc. At that time I incidentally mentioned that a friend and myself had begun the examination of fine papers for a certain purpose.

Explanation of Plate 39.

FIG. 1.—Flax. From a fine example which was used in spinning at Flatbush, Long Island, in 1821.

FIG. 2.—Linen fibre. Ready for paper-making.

FIG. 3.—Linen paper. Extracted from a Michigan Central R. R. bond dated 1872.

FIG. 4.—Letter paper. Water-marked "Royal Irish Linen." Proves to be a mixture of some linen and much cotton.

FIG. 5.—Sea Island cotton. Shows twist in the fibres, but is not sufficiently enlarged to show any diagonal plaid structure.

FIG. 6.—The "Suspected Paper." Purported to be linen, but it proves to be a mixture of some linen, much cotton, some poplar-wood fibre, etc.

Explanation of Plate 40.

FIG. 7.—Longitudinal-radial section of the wood of *Populus monilifera* Ait., exhibiting the peculiar screen-like blocks of the medullary rays noticed in specimens of paper made from the pulp of this wood.

FIG. 8.—Poplar-wood fibre pulp. Made by "soda process."

FIG. 9.—Longitudinal-radial section of spruce wood.

FIG. 10.—Spruce-wood fibre, pulped. "Sulphite process."

FIG. 11.—Reputed "cottonseed-hull pulp." Proves to be fibre of coniferous wood.

All the figures are enlarged about 250 diameters.

The reason of this examination was that my friend, Dr. T. B. Stillman, professor of analytical and applied chemistry at the Stevens Institute of Technology, in Hoboken, received from a firm of engravers a specimen of paper which had been offered to them as "linen paper," suitable for some of their purposes. They wished Dr. Stillman to make a hasty determination of the paper and report as to its constituents. He undertook to do this by chemical means, but, on account of a similar reaction by nearly all vegetable fibres composed of cellulose, his analysis proved unsatisfactory to himself. He looked over many written authorities upon the investigation and manufacture of fine paper, and concluded that chemistry alone would not solve his difficulty, and that, if the constituents were to be fully determined, the microscope must be brought in to complete the analysis.

He asked me to assist him in the case, as he was not an expert in the handling of the microscope. I, who had never undertaken the systematic examination of paper, however, consented to aid him in the analysis of this, which we shall call our "suspected paper." Like many microscopists, I had casually examined fibres of linen, cotton, silk, etc., and had in a general way run through sections of various woods; but when at this time I undertook to examine various papers and paper pulps, I, for want of experience, found myself entirely "at sea." This "suspected paper" seemed to more particularly puzzle us. It had in its appearance much of the straight-fibred characteristics of linen, but it also showed cotton, and in the tangled mass upon the slide other matter cropped out with which I was unacquainted. In short, after making numerous examinations and comparisons with several woods and a variety of papers and pulps, we arrived at the conclusion that this "suspected paper" was composed of a little linen, much cotton, and some wood, mainly poplar; it having probably been largely made up of old or repulped paper, heavily sized and nicely finished. I have but a small piece of this paper here, which I offer for examination.

Up to this period I was not aware of the use of so large an amount and variety of woods in the manufacture of writing and other of the finer papers, supposing that merely newspapers, books, and printers' common stock were made from wood pulps. Much less did I know of the various misrepresentations of the paper trade until later, when, to my surprise, we found high-class paper manufacturers, both in this country and in Great Britain, who water-mark their products as "Pure linen stock," "Royal Irish linen," "Pure parchment, one hundred per cent chemical fibre," and other high-sounding names, employed admixtures of cotton and various woods, more particularly spruce, some varieties of poplar, fir, white pine, etc., as may be seen by slides Nos. 4–6 and several which are not numbered (Plate 39, Figs. 4 and 6).

Having made this discovery, and now being upon our guard, in order to ascertain what was published upon this topic we looked up some of the literature upon the proper means of detecting admixtures in paper.

We could find but little that was very definite or of much value in the English or American works, but found much in German concerning investigations in progress, although these investigations were usually conducted by intricate and tedious processes.

The work in this line performed and in progress in the German Kais. Königl. Versuchstation at Berlin appears to be the most valuable that came to our notice. Of these I have made a few extracts, which I will give further on if time permits.

The various modern processes in pulping a variety of the vegetable fibres, and the admirable texture and finish given to many of the finer manufactured papers, make it very difficult to get a qualitative, much more a proper quantitative, analysis of these products.

It might be well at this stage to submit a brief outline of the general manner in which paper is manufactured, in order to have you comprehend why it is so difficult to distinguish, in this progressive age, the superior all-linen stock from the cheaper mixtures of cotton, woods, etc. At the head of the list stands the ancient papyrus, of which the first was probably made in Egypt from a species of reed belonging to the family of Cyperaceæ, or sedges. A fine paper was also early made from the inner layers of the cuticle of the mulberry and other trees, laid side by side, and a second layer being placed at right angles; all were wetted, pressed together and dried in the sun, beaten smooth with a mallet, and polished with a piece of ivory or shell.

The Aztecs made a kind of paper from the leaves of the maguey plant, which plant is still grown extensively in portions of Mexico; but the modern Mexican prefers to brew from this plant his "pulque," the national beverage, and his paper is now made from other substances, much like our own.

To the Chinese, however, has been attributed the manufacture of the first paper made upon modern principles, viz., that of pulping vegetable fibres.

My attention was called to a work in German and published in 1887, entitled "Die mikroskopische Untersuchung des Papiers mit besonderer Berichsichtung der ältesten orientalischen und europäischen Papiere," by Dr. Julius Wiesner, professor of botany and vegetable physiology in the University of Vienna.

This book, a quarto of eighty-two pages, is mainly intended as a history of paper-making, and gives the constituents of writing papers manufactured from the ninth to the nineteenth century, showing the earlier papers to consist of more or less wool mixed with hemp and linen; and later, as made in the eleventh to the fifteenth century, a mixture of wool, linen or hemp, and cotton, heavily sized with glue or starch, prevailed; and in the fifteenth century the use of wool in paper ceased.

After this, according to this author, the European papers were made of linen and small quantities of cotton combined, but in the early part of the present century cotton was used in larger quantities as an adulterant of linen and hemp papers. Later on cotton was used as the sole ingredient of the cheaper writing papers.

This author gives the names of many letters and public documents from which paper has been taken and examined by himself and others, working together on these historical investigations at this time. He also mentions the labors of Briquet and Caruel in their microscopical researches on papers used from the eleventh to the fourteenth century inclusive.

Among the older papers examined by Dr. Wiesner there are some found in the tombs of Egypt; others from Arabia, Damascus, and other portions of Syria; also many important documents in Italy and of various parts of Europe from one thousand years ago to the present century. In each case he states from what materials these papers are manufactured, gives the title of the writing or document and the date thereof, making a curious and interesting history.

The usual processes of paper-making are well known, but I will mention enough of them to indicate why it becomes so difficult to detect adulterations and admixtures therein, either chemically or microscopically. The chief reason why we cannot separate the component substances of paper microscopically, is because the linen or cotton rags, or both of these mixed, are placed in the "beating machines," equipped with long knives and flail-like arms, which tear up and beat out all traces of their original textile nature. With protracted maceration in strong alkalies the mass is reduced to a jelly-like pulp. This mass is retained in hot water for many hours, bleached with chloride of lime, sized with gelatin, or resin soap, and alum dissolved in soda. China clay is sometimes added to improve its weight and surface rather than its quality. One would think that these tearing, macerating, and chemical pulping processes would be quite sufficient to obliterate all traces of the original fibres; but when to this is added old paper to be reworked, then the difficulty of optically separating the original fibres becomes extremely aggravated, so that while one knows upon microscopical examination that he has not pure linen paper before him, he nevertheless finds himself embarrassed in determining what he sees in the broken-up and tangled mixture, however carefully he may arrange it upon the slide. You may demonstrate this for yourselves by looking at slide No. 6, this being our "suspected paper" which was offered for linen (Plate 39, Fig. 6).

When, however, a percentage of wood pulp ready for paper-making is mixed with linen, or linen and cotton pulp, and especially if the wood is of the coniferous order, such as spruce or white pine, etc., then the woody admixture is quite easily discerned, although it may have been cut to pieces and pulped.

In slide No. 8 you will see a fair example of a spruce-pulp paper by one of the chemical reductions, known as the "soda process" (Plate 40, Fig. 8).

Now as to the modes of manufacturing wood pulps for paper-making.

There are two general methods, one known as the "mechanical" or "ground wood," and the other as the "chemical" pulp process. These are again subdivided into "sulphite," "soda pulps," etc. By the "mechanical" or ground-wood method any suitable wood is taken, usually, on account of cheapness, the edgings, slabs from sawmills, small cordwood, and other waste stock. In the "Voelter" process, which is German, the defiberer, or mill, consists of a coarse cylindrical stone revolving rapidly, against which the pieces of wood are held by springs. The water which flows through assists in reducing the fibre so finely that the subsequent chemical treatment is simple. The "mechanical" processes, however, break up the fibres into short particles, thereby reducing the strength of the pulp and permitting less of this pulp to be mixed with linen or cotton, on account of the consequently greater friability of this woody matter.

Among the various "chemical" wood-pulp processes is one in which the wood is not disintegrated, as by the "mechanical" or ground-wood methods, but convenient-sized pieces are placed in a steam-tight vessel and boiled with about twenty per cent of strong caustic soda under a pressure of ten to fourteen atmospheres. In another, by the popular "Mitscherlich" patent method, bisulphite of lime is used instead of soda; and the best wood pulps are prepared by the several "sulphite" processes.

I show you here several examples of these methods in sheets of dried pulp, and finished papers, Nos. 12 to 17, with the color action of various reagents upon them, which were treated by Prof. Stillman, and which I will explain after I shall have finished this paper. The mounted slides of the corresponding numbers are on the stands for your inspection.

Now, as if the several methods of paper-making, as briefly described, were not sufficiently destructive, there is still another curious mode—that is, the converting of cane wood into pulp. By this, the "Lyman" process, the disintegrated cane is placed in strong iron cylinders, called "guns"; these are about twenty-two feet long and twelve inches internal diameter, and are laid on heavy frames. The heads are fastened on both ends, and steam is admitted until a pressure of one hundred and eighty pounds to the square inch is reached. This pressure is maintained for about twelve minutes, when, by pulling a trigger, the covers are suddenly released, and the steam, propelling the mass of disintegrated wood before it, rushes out with an explosion equal to that of a large cannon and may be heard many miles. The charges from these "guns" are fired against an iron target about thirty feet distant, leaving a spongy mass which is then converted by chemical treatment into paper. Besides the mangling of paper stock by the various pulp-making methods, there are still the several processes of finishing, such as bleaching, sizing, and moulding the pulp by means of wire gratings, upon which the setting or hardening pulp rests; a portion of these screens, with figures or names placed in them by means of thinner wires, producing the "water-markings" commonly seen on writing papers.

In addition to these we have the calendering, glazing, filling, and numerous other finishing processes, with which I will not further weary you.

Having now seen these several constituents of paper variously torn, cut, beaten, mangled, shot out of "guns," ground up, dissolved by chemical means, and many of these substances completely transformed from their original condition and the appearances with which we are familiar, how are we to determine what they are? When we consider the great variety of materials used in the manufacture of paper, and yet know that all of them consist of cellulose, which gives a similar reaction chemically, we find that the chemist is debarred from positively identifying any admixture of pulps or finished paper, although he can detect "mechanical" wood pulp unmixed, as we shall see later, by the color demonstrations on the papers, as heretofore mentioned and here exhibited; but beyond this stage chemical tests become unreliable.

We see, therefore, why almost the entire determination of admixtures in paper rests with the microscopist.

It is easy to recognize under the microscope the ordinary materials from which paper is manufactured, such as linen, cotton, various woods cut in thin sections, etc., when each of these substances is in its natural condition and properly mounted for microscopical observation.

Here are displayed before you under magnification not only preparations of the actual materials—flax, cotton, etc.—but also a number of photomicrographs of the same preparations distinctly exhibiting the details (Plate 39, Figs. 1, 2, 5; Plate 40, Figs. 7, 9). In addition to these examples of the simple fibres you will also see here illustrated in the same manner the more intricate specimens of various pulps for paper-making, composed of linen, cotton, mechanical and chemical wood processes, besides one slide purporting to be "cottonseed-hull pulp," but which instead proves to be of coniferous wood, as you will readily see from its well-known characteristics (Plate 40, Fig. 11).

Let us go a little further and examine the finished papers, portions of which we have here upon our slides. Previous to mounting these Dr. Stillman prepared them for the purpose of eliminating the sizing, rosin, filling, etc., with which they were finished. This is accomplished in this manner: Cut the finished paper in small pieces, and place them in a beaker, adding a sufficient quantity of a solution of caustic soda (caustic soda one part, water thirty parts). Digest the paper just below the boiling point for about fifteen minutes. Pour off the liquid and replace with double the quantity of distilled water. Pour off this water and wash once again in the same manner. Add the same quantity of a solution composed of fifteen parts of distilled water to one of hydrochloric acid. Digest ten minutes with a gentle heat. Pour off this liquid and wash in warm distilled water about three times, then dry the paper for mounting in glycerin or balsam. In order to get some contrast in the fibres for photographing, stain them lightly with hæmatoxylin.

As an example of pure linen paper shown here, and which is becoming somewhat scarce in the market, I have extracted a specimen from a railroad bond now twenty-two years old (Plate 39, Fig. 3). We have here also a specimen of a sheet which is water-marked "Royal Irish Linen," a letter paper sold at a good price. Inspect this under a microscope, and you will have no difficulty in finding a fair proportion of cotton mixed therein (Plate 39, Fig. 4). In the slide (No. 6) already mentioned as from our "suspected paper" you will see scattered through it but little linen, and will see some woody indications, with plenty of cotton; but, on account of the tearing-up, pulping, and repulping process it has undergone, it will be found very difficult to eliminate the various disintegrated fibres therein contained. The sheet from which the specimen on slide No. 13 was taken is called by the manufacturer, "parchment paper." I regret to have mislaid this sheet. This was a strong, nicely glazed, and highly finished paper. From its name and general appearance one would think it might be pure linen paper, but you will find nothing but cotton in the specimen under the microscope. We have not known any attempt of the manufacturer to palm off papers made wholly of wood for linen, but the several kinds of wood pulps are frequently mixed with linen and cotton-rag pulps, and when finished are sold for high-class paper, while the cheaper grades are made almost entirely from wood pulps.

Both in the "mechanical" and "chemical" wood paper systems the woody markings may be distinguished by the aid of the microscope, and more particularly the coniferous fragments (Plate 40, Figs. 10, 11).

Poplar-wood fibre, when torn up, somewhat resembles cotton, but there is at least one distinguishing feature, even among the disintegrated "mechanical" pulps—that is, the tangential fragments have among them particles bearing a grate- or screen-like appearance; some of these evidences may be seen in slide No. 7, a section of the wood of *Populus monilifera* (Plate 40, Fig. 7). Slide No. 16, being paper of the Singerly Pulp and Paper Co., also exhibits this peculiar feature, indicating poplar wood "ground" up by the "mechanical" process. Slide No. 17 is of Woolworth & Graham's "ground wood pulp," which also shows a little of the poplar character, but the mass is so full of short fibre as to be practically unrecognizable, and is only fit for printers' low-grade work. The chemical tests, however, show plainly by their peculiar colors that this is "ground wood."

We have here a sheet of dried pulp from Norway, called "Eker," which is shown by the microscope to be composed of spruce wood, and, as you will see by its bright-red color in its chemical reaction, when I slightly touch it with para-phenylendiamine hydrochlorate, is proved to be "mechanical fibre."

I will not go into further detail regarding the varieties of paper intended for the higher classes of work. It is patent that there is much yet to be learned about the methods of detecting mixtures in paper, even for the ordinary qualitative tests; and as for quantitative analysis, we have found no better method than those adopted at the German testing station at Berlin, where an eyepiece micrometer, ruled in squares, is used to count, as best may be, the several fibres or parts of fibres of each admixture contained in any square or number of squares, and by this means to arrive at the average proportions of each kind of material contained in the mass.

A glance through the microscope at some of these paper compositions will, I think, satisfy you that, even after making many measurements and taking the average of them, the final determination will be far from correct, on account of the thoroughly intermingled condition of the various substances; the differences in the dimensions of the divers kinds and shapes of the fibres; the broken portions of many of these; as well as the impossibility of discriminating between the ingredients in their disintegrated state. For the reasons given I have not, up to this time, attempted a quantitative determination in mixed or adulterated papers. For similar reasons no fixed rule can be laid down for optically separating the constituents in the finer papers, except by long and diligent practice with the microscope, thereby training the observer's eye and mind for the discrimination necessary in detecting such matter as one finally becomes familiar with by certain details he has previously recognized, and by comparison with the elements which form the component parts of the usual admixtures or adulterations named in the subject of this evening.

I am thankful to Prof. Stillman for bringing this matter to my attention originally; for the valuable aid he has given me in his chemical preparations; for collecting examples of paper stock; and in pointing out much of the bibliography bearing upon this class of investigation. You are also indebted to him for the color reactions which he has so well shown, by means of the numerous examples of pulps and paper treated by him which I have laid before you, and which I will briefly explain when I apply some of these reagents to show you their rapid action on some papers.[1]

We are under obligations to Dr. E. G. Love for the photomicrographic illustrations of many of the slides upon the tables, which enable us to more readily conceive the appearances of the several original substances here shown, and the results when these are made into pulp and paper, as I have already described.[1]

---

[1] On account of the chemical investigations by Prof. T. B. Stillman, now in progress and relating to papers and their constituents, I do not mention at this time any of the other chemical reagents shown here, but hope that he will in the near future give for publication, in a chemical or other technical journal, a more complete means of chemical identification than has hitherto been known.

I regret that I am unable to throw more light upon what we have discovered to be an intricate and vexatious subject; but if no further advantage shall be attained from our earnest efforts at this time, I hope, at least, that other members will be induced to take up not only the further investigation of paper admixtures, but also the analysis of many of the familiar products manufactured and in common use, with a view of making known to the world what adulterations they severally contain.

Moreover, I have chosen a utilitarian theme on this occasion whereby the microscope is applied to the economic arts; may I be pardoned, therefore, for the lack of truly scientific work which might be expected in an annual address before such an association as ours ? If no other benefit shall result therefrom, we as microscopists, when engaged in kindred lines of research where science is applied to the practical arts, may perhaps disprove the imputation that we can claim no independent position in either the arts or sciences.

---

[1] Of the numerous photomicrographs made by Dr. Love, we have had portions, two inches square, cut from eleven of them, and reproduced in half-tone by the photo-engraving process, and inserted in this publication in two plates.

THE COMPARATIVE ANATOMY OF THE VERTEBRATE SKIN.

BY GEORGE WILLIAM KOSMAK.

(*Read January 19th*, 1894.)

I. Introduction.

The subject to which I ask your attention this evening presents to both biologist and microscopist a varied and fascinating line of work in original research and investigation. In its morphology and physiology many points are still doubtful and obscure, awaiting the biologist's explanation and elucidation; while to the working microscopist there is held forth an equal opportunity in a field where little satisfactory work has yet been done—*e.g.*, in the technique and new methods of sectioning and staining.

The study of the skin, anatomically and physiologically, is a subject vast and extensive, with an accompanying literature equally so. The latter, however, consists of a mass of detail, much of which is unimportant. The beginner must wade through

---

Explanation of Plate 41.

FIG. 1.—Diagram of Fish Skin. Transverse section, illustrating general structure. (After *Wiedersheim.*) S C, striated cuticular border of epidermis; A, slime cells; E, epidermis; D, derma; K, goblet cell; L, granular cells of *Petromyzon;* B, blood vessels; V, vertical connective-tissue bundles; H, horizontal connective-tissue bundles.

Explanation of Plate 42.

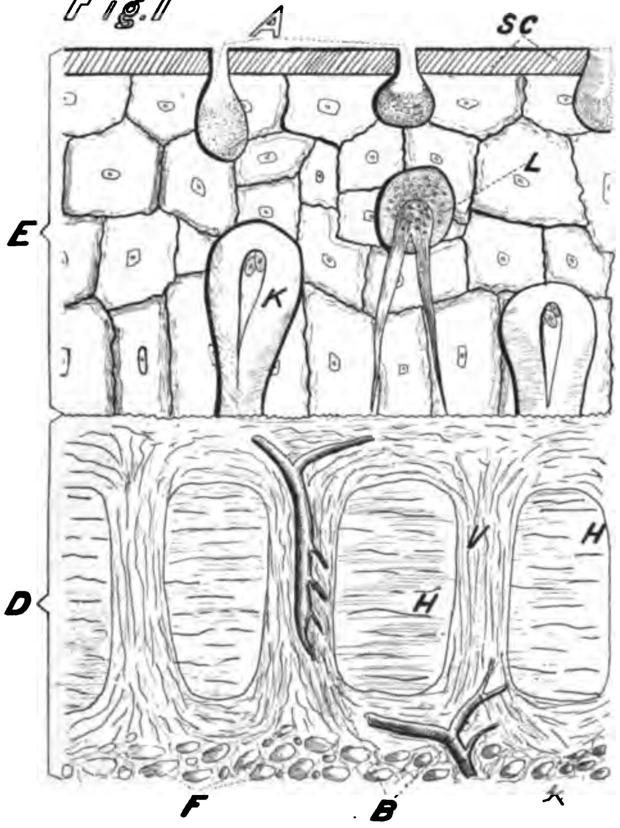
FIG. 2.—(*a*) Diagrammatic cross-section of skin of larval Salamander; (*b*) ditto, of adult form. (After *Wiedersheim.*) E, epidermis; D, dermis; S C, striated cuticular border of E; C, stratum corneum; M, stratum Malpighii; P, pigment; O, subcutaneous layers of muscle; B, blood vessels; N, epithelium of glands; X, Y, integumentary glands; T, muscles of glands.

Explanation of Plate 43.

FIG. 3.—Feather Development. Diagrammatic. (After *Studer.*) *a*, *b*, *c*, *d*, *e*, *f* denote successive stages. C, stratum corneum; M, stratum Malpighii; D, derma; F, F′, feather germ; P, pulp; Q, quill; B, barbs; B′, barbules *c* is a cross-section of the feather germ in *b*, showing the ridges of Malpighian cells covered by the horny layer of epidermis.

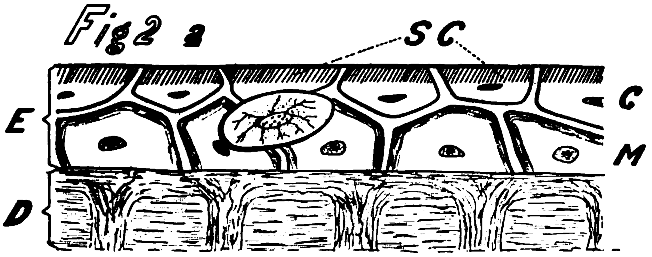
FIG. 4.—Hair Development. Diagrammatic. *a*, *b*, *c*, *d*, *e*, *f* denote successive stages. C, stratum corneum; M, stratum Malpighii; D, derma; F, hair follicle; B, blood vessels; K, hair knob; G, sebaceous gland; P, hair papilla—in *e* and *f* are indicated two stages in its formation; in *f* it has become vascular.

Fig. 1

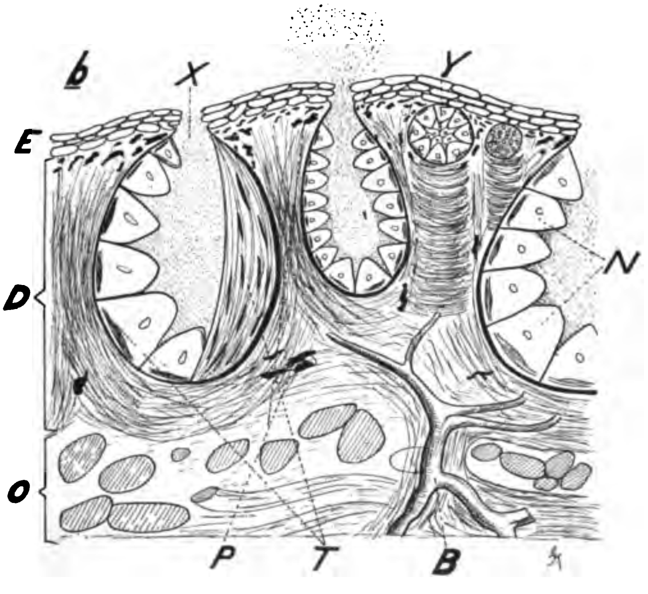


VERTEBRATE SKIN.

Fig 2 a



b



VERTEBRATE SKIN.

Fig 3

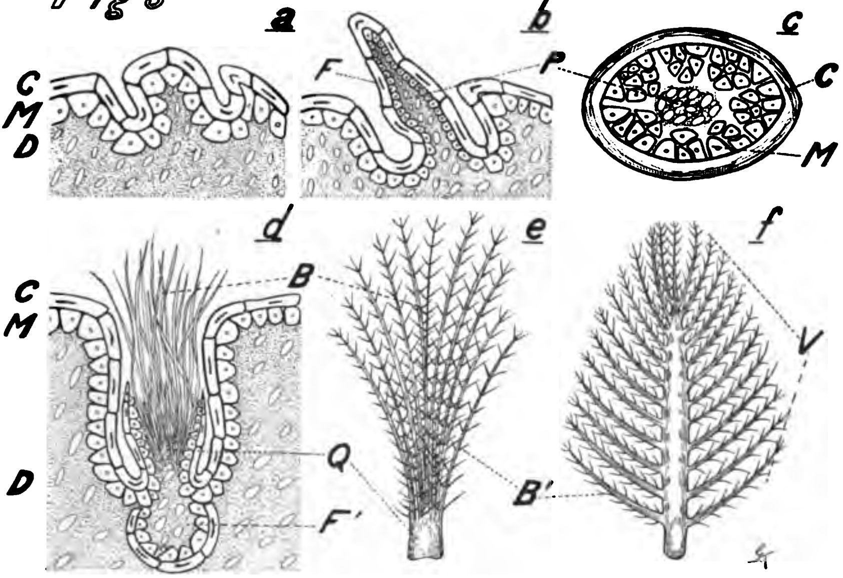
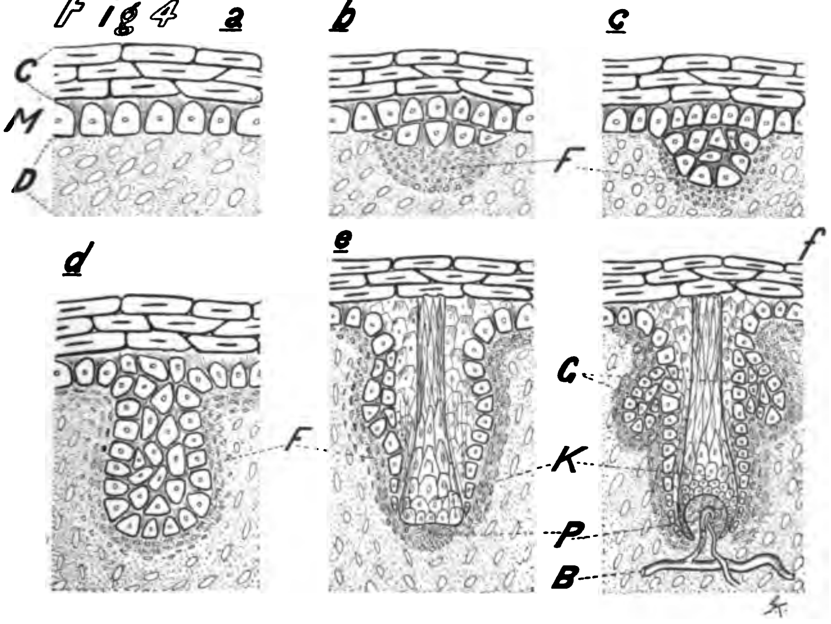


Fig 4



VERTEBRATE SKIN.

it all, as there is no general work on the subject that I have yet found—no manual which treats of the anatomy and physiology of the skin in a comparative sense, with a section devoted to microscopical methods. The need for such a work is evident.

Owing to this magnitude I can only speak of generalities. I will first say a few words of the skin in general; then take up the several types of vertebrates, and speak of their most characteristic structures as derived from the skin; and finally make brief mention of the theories of homologies and correlations that have been noted in the higher types.

II. The Skin in General.

The vertebrate skin, as derived from the embryo, consists of two layers, a superficial ectodermal and a deeper mesodermal layer. The former is called the *epidermis* (scarf-skin), the latter the *dermis* (corium or cutis). The skin, like a mucous membrane, consists of an epithelium resting on a connective-tissue basis, the epithelium forming the *epidermis* made up of a few or many layers of cells. The surface of the *dermis* is thrown up into a number of elevations, called papillæ, which differ in form, size, and complexity in different regions of the body and with the position in the animal scale. The epidermal or outer layer does not follow this papillary contour of the dermis, and when the two layers are carefully pulled apart and examined (*e.g.*, in the human skin) the papillæ appear to plunge into and be covered by the more even epidermis, although the outer surface is well marked by ridges and furrows, such as we can plainly see in the palm of the hand. These papillæ are the end organs of that most important sense, *touch*, and in the lower forms may also function as other sense organs, which will be spoken of later on.

The outer or epidermic layers always consist of cells only, while the derma is made up also of connective-tissue fibres, as well as of elastic and contractile elements. In the epidermis two layers can always be distinguished—an outer, composed of horny cells, and therefore called the *stratum corneum;* and an inner, made up of soft protoplasmic cells, the *stratum Malpighii.* The latter really serves as a matrix for the regeneration of the outer, horny layer, the superficial part of which is continually scaling off. Nerves, glands, pigment cells, bony structures, and blood vessels occur principally in the dermis. So-called epidermic structures, such as skin glands, hairs, feathers, nails, hoofs, claws, bristles, etc., are formed from the epidermis or outer layer. These will be treated of in those types in which they are most characteristic, and we can then also see how environment, both natural and artificial, has brought about many changes both in their form and function. This need not appear strange or wonderful when we consider how accessible the outer surface of the skin is to external modifying influences. Before beginning with our types of animal life and illustrating the modifications that occur, the two primary divisions of the skin must be borne in mind—an outer layer, protective, and an inner layer, nutritive in function.

A few words in regard to the general physiology. Broadly speaking, the waste products of the body are *urea*, *carbon dioxide*, *water*, and various *salts*. These leave the body by one or other of three main channels: the *lungs*, the *kidneys*, or the *skin*. The lungs discharge most of the carbon dioxide and some water; the kidneys, the urea and allied bodies; the skin, a small amount of the salts and nearly all the water. The skin is therefore the great evaporating agent, and the discharge of waste products by this channel we know as perspiration or sweat.

It has been proven that death would ensue in an animal in which this cutaneous evaporation was prevented by covering its body with an impermeable varnish which retained the sweat in the glands, which thus acted as a poison.

The skin in the lower forms can also take the place of lungs. If the lungs of a frog be removed he will continue to live for some time, consume oxygen, and produce carbon dioxide, as in the ordinary mode of breathing, thus showing that respiration can be carried on efficiently by means of the skin.

Having briefly noticed its main anatomical and physiological features, we will now take up the skin comparatively in the five great classes of the vertebrates, and examine its most prominent characters in each.

III. The Classes of Vertebrata.

A. Fishes.

In certain members of this class we find conditions which have undoubtedly been inherited from invertebrate ancestors. Thus in the outer epidermic layer of many Fishes (*Amphioxus*, e.g.) we find a striated border, which can be imagined to consist of coalesced cilia, and in the larval condition we find the free-moving cilia themselves on the outer surface of the epidermis (Fig. 1, S C). Here, as in many other instances, we can see gradual transitions from lower to higher forms.

Glands, such as we find in higher vertebrates, are usually not present in Fishes. The skin secretions which we do find come from single cells or canals (Fig. 1, A). The fluids which they contain probably protect the skin from the action of the water or ward off the attacks of fungoid growth; and it has lately been determined that certain of them function also as sense organs. Other secreting cells are also present, the so-called "*goblet cells*" (Fig. 1, K), whose function has not been definitely determined.

The most marked characteristic of the integument of Fishes is in the scales. These lie in connective-tissue pouches of the derma, and are formed as ossifications of the latter. In the higher types of Fishes they are covered by the epidermis throughout life, but in *Ganoids* (Gar-pikes, etc.) and *Elasmobranchs* (Sharks and Rays) this is only the case in the larva. In the adult they are free and projecting. The primitive form of the common fish scale, as we see it in the Perch, for example, was probably an ossification in the derma, which we call the basal plate with projecting processes, the derm denticles. The transitions which these have undergone from one form to another constitute a very interesting series. In many Fishes, especially fossil, they form a complete protective armor by their fusion, as in the well-known armored South American catfishes.

The next factor to consider is pigment. This always originates in the derma, and to it is due coloration. In endeavoring to account for its presence in the epidermis it has been asserted and observed that white blood corpuscles carry pigment granules to the outer layer, where they take on amœboid movements, and then break up into many small pigment-containing particles, which are taken up by the epithelial cells. The distribution of pigment over the body varies with the species and individual. It is also subject to changes in environment, and is under direct control of the nervous system. That it changes in order that the animal may adapt itself to its surroundings, has lately been demonstrated in the case of the common English Sole. As is well known, the color of its upper side approximates very closely the tint of the muddy bottom upon which it lives. However, when placed under conditions which permit the access of light to the lower as well as the upper side of its body, pigment will also be developed on that side which formerly showed no trace of it.

We now take up a very important derivation of the integument —*sense organs.* Their main function is probably the perception of mechanical irritations of the surrounding water, but they may also have to do with the perception of sound. As elements we have two kinds of cells: rod-shaped sensory cells, connected by nerve fibres with the central nervous system, and the supporting cells, which lie between the others and serve as connecting and isolating material. The surrounding medium is always kept moist by various secreting cells In those animals which give up an aquatic life in the course of their development and come to live on land, the end organs of the nerves pass further inward, the rod-shaped cells disappear, and we have two kinds of nerve endings in the skin: terminal ganglion cells and free nerve endings. With Fishes we must include Amphibia in the consideration of these sense organs, as the two types are very closely related. "They consist of a central mass of cells, arranged in the form of a rounded and depressed pyramid, and of a peripheral mass grouped around the former. The central cells are in connection with nerve fibres, and each bears on its free end a stiff, cuticular hair; these are to be looked on as the proper sensory cells, and the others merely as a supporting medium." Where these hairs project freely from the epidermis they are surrounded by a delicate, protective, hyaline tube, which opens into the surrounding water, and into one end the sensory hairs project. These organs are at times distributed over the whole body, but as a rule only in certain well-defined tracts; those along the sides from the head to the tail form the so-called organs of the lateral line. Others are found in depressions or canals formed by scales, and then, of course, the protective hyaline tube disappears. Another form of sensory organs are the end bulbs, which in Fishes serve as tactile organs, but in higher forms develop into organs of taste.

B. Amphibia.

The skin of Amphibia, as in the Salamander, exemplifies a transitionary stage from Fishes to Reptiles. Thus, in the aquatic larval forms, two sharply differentiated layers of the epidermis can be made out, the superficial one with that same striated cuticular border which we find in Fishes (Fig. 2, S C). Later, with advancing development, the layers of the epidermis become more numerous, involutions toward the derma take place to form a great number of globular and tube-shaped glands (Fig. 2, X, Y, N). This richness of glands is a marked feature of the skin of Amphibia, and to it they owe their moist and slippery nature. Their secretions serve a variety of purposes, from merely supplying moisture, to a protective function in the form of poison.

Pigment is deposited in great quantities, partly in and partly between the cells of the derma. Here, as in other forms, we see that wonderful adaptation to environment, as exemplified in the well-known green tree-frog and the sandy-colored horned toad of our Western deserts.

Calcifications may also occur in the derma, but they were more abundant in fossil than in modern forms. Some of the integumentary sense organs of this group have already been mentioned in connection with those of Fishes. Another form, which is first met with in the tailless Amphibia (*Anura*), is the tactile spot, consisting of a group of cells in a typical form of papilla, which functions as an organ of touch.

C. Reptiles.

In taking up this group for examination we notice two prominent characters: the formation of scales and other horn-like structures, and the almost total absence of integumentary glands. Scales can here be dismissed with a few words. They are all formed by a change in the epidermis, in which the derma takes part later on. Many widely differing forms all originate in this manner, and can be classed in general with the feathers of birds and the hair of mammals. The scales and rattles of snakes, the tortoise shell of chelonians, claws, prickles, and warts, are all epidermal.

In this group pigment plays an important rôle. The chameleon is a time-honored and well-known example of the change of color to agree with surroundings. In addition to pigment the formation and structure of the scales in relation to the light-rays may also have something to do with the general effect.

Integumentary sense organs are represented in Snakes, and also in Birds, by tactile cells surrounded by connective-tissue pouches, with septa separating the individual tactile cells and thus forming a tactile corpuscle.

Dermal ossifications were more developed in ancient reptiles than in those of the present day. Crocodiles, some lizards, and principally the chelonia, still maintain dermal structures.

D. Birds.

When we come to examine this group the most characteristic integumentary structures are the feathers, and these will therefore require the greater part of our attention.

Ordinarily feathers appear to be inserted over the entire body of a bird, but on closer view they will be found, with but few exceptions, in certain regions only, called *feather tracts*, separated from each other by naked stretches of skin. These tracts vary in number and position with different genera, as do also the shape and size of the individual feathers. In a general way feathers develop as follows : At the point where one is destined to be formed occurs a slight upheaval of the dermal tissue, followed by the epidermal layer, and thus creating a papilla. As this papilla grows outward and forms a bluntly-pointed cone (Fig. 3, *a*), its base sinks gradually inward ; the epidermis immediately surrounding follows and forms a pocket around the elongated papilla. This papilla is the *feather germ* (Fig. 3, *b*, F), and the pocket constitutes the *feather follicle* (Fig. 3, *b*). The papilla is thus made up of the two layers of the epidermis on the outside, acting as a covering for the mass of dermal cells in the interior, the *pulp* (Fig. 3, *b*).

As the feather germ grows the cells of the inner epidermal or Malpighian layer increase rapidly in number, and grow toward the centre of the germ in a series of ridges, thus forming folds between them which run the length of the *germ*. Immediately surrounding this is the outer, horny layer of the epidermis (Fig. 3, *c*). Each separate ridge of these internal cells now becomes horn-like, and the central pulp substance dries up. We thus have a bundle of horny rays surrounded by an outer sheath, and of these the pencil-like structures seen on the bodies of newly-hatched birds consist. The outer, horny covering finally breaks off, the rays or barbs become free, and a *down-feather* is formed (Fig. 3, *d*). The lower portion remains in the skin as the *quill*, and the entire structure may remain or be replaced by definite feathers. In such case a second germ forms at the base of the first, the papilla grows rapidly, undergoes nearly the same changes as the other, the embryonic down-feather is pushed out and may often be found attached to one of the barbs of the new feather. At first the two kinds are much alike, but, in the second, one of the rays becomes rapidly thickened and forms a *stem*, to which the barbs are attached on each side, with their *barbules* (Fig. 3, *f*). This theory of feather development, as advanced, with perhaps some slight differences of detail, by Studer (1873) and Kerbert (1876), has been, and is to a great extent even to this day, accepted as the simplest and most probable.

In Birds we have no trace of true dermal bones, and also a marked deficiency in glands, the only ones being the uropygial glands at the base of the tail, whose secretions serve to oil the feathers. Many important epidermal structures, in addition to feathers, are found in this group; such are: claws, spurs, foot scales, and beak sheaths.

E. Mammals.

We now come to the highest class of the vertebrata, and, as in Birds, we will consider first its most prominent feature—namely, hair. Histologically this is quite distinct from the hair-like structures of Birds and Reptiles, which have no true hair. Its development is very interesting.

At the spot where a hair is to be formed an increase in the number of cells of the inner epidermal or Malpighian layer takes place, forming a dome-like mass directed toward the interior (Fig. 4, *a*, *b*, *c*, M). The cells of the derma now arrange themselves in mantle form around this mass in a kind of pocket, destined later to become the outer hair sheath. This proliferation of Malpighian cells now assumes a bottle-shaped form, and a differentiation of the constituent cells into central and peripheral portions takes place (Fig. 4, *e*, F, K). The central part consists of elongated cells and grows rapidly outward to form the *hair shaft*; the peripheral layer now becomes a *sheath*. The base of the shaft will now be observed to have assumed a knob-like form; an infolding of its base occurs to contain the nutrient blood vessel (Fig. 4, *e*, *f*, K, B, P). Sebaceous glands for oiling the hair are also produced by proliferations of the Malpighian cells (Fig. 4, *e*, *f*, G). When a shedding of hair takes place a new papilla may be formed at the base of the old one.

Hair plays a very important part in the life history of the Mammalia. It is their most distinguishing characteristic, and here, as much as in any animal type, we can see the great protective value of integumentary derivations, the very nature of the hair mass retaining so large a quantity of the heat of the body.

When pigment is present in Mammals, it occurs in the cells of the Malpighian layer, showing a marked difference from lower forms where it is found principally in the derma.

Epidermic structures are worthy of note in this group. They include many and varied forms: the baleen plates of whales, the spines of the hedgehog and porcupine, the nasal horns of the rhinoceros, the claws of cats and dogs, the bristles of the hog, and many others all belong in this category.

The principal glands are sweat and sebaceous glands. These make up two general classes, the former the simpler, the latter more highly developed histologically. The mammary glands, which characterize this group, can be also looked upon as modified sebaceous glands.

IV. Conclusion.

The five great types of back-boned animals having been examined, it remains for us to consider briefly a few of the relations of the integumentary structures to general organic evolution and to each other.

In the first place, as we have seen, they are divided into two classes: those originating in the derma, in which the epidermis may or may not take part, and those developing from a purely epidermal source. Fish scales and derm denticles are examples of the former; in the lower types they form a complete exoskeleton; but as we ascend in the animal scale it is found that as the endo-skeleton becomes more highly developed this exo- or dermal skeleton grows of less and less importance, until finally it disappears altogether. Epidermal structures (hairs, feathers, e.g.) have now become of greater value. It seems that with the higher development of the internal skeleton and the degeneration of dermal structures the epidermal derivatives have grown in importance.

Scales, feathers, and hairs are undoubtedly derived from a more primitive, common condition, for in their individual developments they show many points of resemblance. The intermediate form between reptile-scale and bird-feather has not as yet been found; but feather and hair both point to one antecedent type, found at the present day in the spurs of birds and the hair of Monatremes. For in *Echidna* we find a hair without any medullary substance, and then succeeding stages to typical hair. The spur is very likely descended from a hair with a thickened outer layer. This structure may break up into rays and form a feather, or become flattened out to form a scale.

The relations of these structures to each other have furnished material for many theories, but we still await the final and definite settlement of the question. This is but one of the many problems which constitute such a fascinating field of research to the modern biologist, who can accomplish wonders if he would but attempt to elucidate and harmonize, or else disprove and expunge, some of the many theories of his predecessors regarding these questions.

IN MEMORIAM.

REV. SAMUEL LOCKWOOD, PH.D.

Dr. Lockwood died at his residence, Freehold, N. J., on January 9th, 1894, in the seventy-fifth year of his age.

He was born at Mansfield, England, on January 20th, 1819, and was brought in his infancy to New York City, where he received his education, graduating from the New York University in 1847. During his university course he accepted the position of assistant editor of the New York *Sun*, offered him by the editor, Mr. Moses Y. Beach. Taking a theological course at the Theological Seminary of the Reformed Dutch Church, at New Brunswick, N. J., he graduated from that institution in 1850; received his ministerial license the same year from the Classis of New York; and immediately entered upon his first pastorate in the Reformed Church at Cortlandtown, Westchester County, N. Y which position he held until 1852. He then filled successive pastorates in Reformed churches, at Gilboa, N. Y., from 1852 to 1854, and at Keyport, N. J., from 1854 to 1869.

In 1867 he was appointed Superintendent of Instruction for Monmouth County, N. J., and for a more central position in this field of labor he moved his residence to Freehold in 1870. It was in this office, which he held until the time of his death, that he rendered service in behalf of public education which will long be remembered for its faithfulness and efficiency.

An interested student of nature from his youngest days, he possessed the enthusiasm, patience, and assiduity which especially succeed in exploring and interpreting the secrets of wonder and beauty veiled from the careless crowd. He took delight in announcing to others what he had learned, as is evidenced by his numerous publications during many years in scientific serials of this and foreign lands, and by his numerous addresses before scientific bodies of our own country.

During his pastorate at Gilboa, Schoharie County, N. Y., he made a special study of the local geology, which resulted in discoveries confirming opinions of the grandeur of the Devonian period, and in a notable palæontological collection, now at Rutgers College, New Jersey. It was of this collection that Prof. George H. Cook, afterward State Geologist of New Jersey, is said to have exclaimed, on displaying it before the students: "If Hugh Miller were living he would want to cross the Atlantic to see it."

At Keyport, N. J., he found a different but no less fascinating field of nature spread out before him, which he enthusiastically cultivated, and in relation to which he issued various noted publications on palæontology and marine zoölogy. It was during this period—1867—that the New York University conferred on him the degree of Doctor of Philosophy.

Dr. Lockwood was an expert microscopist, using his knowledge of the instrument especially in lines of public instruction and benefit. He was one of the founders of the New Jersey State Microscopical Society, and for some years its President. He was elected an Honorary Member of the New York Microscopical Society in 1884, and his interest and zeal in the welfare of this organization are evidenced by his many instructive and valuable addresses, and by his presentation of objects through these years very nearly to the close of his course.

He was possessed of admirable traits of character. Integrity, good-will, and firmness have left him an irreproachable record. His extending knowledge and facile, accurate expression have made him a desired leader and manager of affairs in his lines of duty. Reverence guiding his enthusiastic unfoldings of nature always tended to point the hearer to the Creator. And a kindly disposition, pervaded by a vein of humor, made him a desirable companion. His death will leave a void in the hearts of many acquaintances and friends.

PROCEEDINGS.

Meeting of January 5th, 1894.

The President, Mr. Charles S. Shultz, in the chair.

Thirty-one persons present.

Annual reports were presented by the Treasurer, Librarian, Recording Secretary, Corresponding Secretary, and the Committee on Publications.

The committee appointed December 15th, 1893, to formulate action on the death of Dr. Paul Hoffman, reported as follows: "Since it has pleased Providence to take from us our friend and fellow-member, Dr. Paul Hoffman, we desire in this manner to express our deep sense of sorrow, and to extend to the bereaved relatives our sympathy."

Mr. Arthur G. Elberg and Dr. Ferdinand G. Kneer were elected Resident Members of the Society.

The President read his Annual Address, entitled "A Microscopical and Chemical Examination of the Admixtures and Adulterations in Papers used for Writing and Engraving." This address was illustrated by numerous objects and photomicrographs, as noted below, and is published in this number of the JOURNAL, p. 31.

This being the stated meeting for the annual election of officers, the President appointed Mr. William J. Lloyd and Dr. Anthony Woodward tellers, and at the closing of the polls the following persons were declared elected officers of the Society for 1894:

President, Charles S. Shultz.
Vice-President, Edw. G. Love.
Recording Secretary, George E. Ashby.
Corresponding Secretary, J. L. Zabriskie.
Treasurer, James Walker.
Librarian, Ludwig Riederer.
Curator, George E. Ashby.
Auditors { F. W. Devoe.
W. E. Damon.
F. W. Leggett.

OBJECTS EXHIBITED.

1. *Bacillus tuberculosis*, under a one-quarter-inch objective of his own construction: by F. D. SKEEL.

2. A "Bulloch Stand" made by E. B. Meyrowitz: by F. D. SKEEL.

3. Flax, from a fine example used in spinning at Flatbush, Long Island, in 1821.

4. Linen fibre ready for paper-making.

5. Linen paper extracted from a Michigan Central Railroad bond dated 1872.

6. "Royal Irish Linen" paper containing a large proportion of cotton.

7. Sea Island cotton.

8. The "suspected paper," purported to be linen, but containing linen, cotton, and wood.

9. "Eker" paper from Norway.

10. Sections of wood of *Populus monilifera* Ait.

11. Poplar-wood pulp, "soda process."

12. Sections of spruce wood.

13. Spruce fibre pulped, "sulphite process."

14. "Cottonseed-hull pulp." Proves to be fibre of coniferous wood.

15. Eleven photomicrographs of the above fibres, taken by Dr. Edw. G. Love.

Exhibits Nos. 3–15 by CHARLES S. SHULTZ.

MEETING OF JANUARY 19TH, 1894.

The President, Mr. Charles S. Shultz, in the chair.

Twenty-five persons present.

The following committees were appointed by the Chair:

Committee on Publications: J. L. Zabriskie, William G. De Witt, Walter H. Mead, John L. Wall, Charles F. Cox.

Committee on Admissions: H. W. Calef, Anthony Woodward, M. M. Le Brun, H. G. Piffard, W. J. Lloyd.

The President announced the death of Rev. Samuel Lockwood, Ph.D., Honorary Member of the Society, and appointed the following committee to formulate suitable action under the circumstances: F. W. Devoe, J. L. Zabriskie, H. G. Piffard.

The Recording Secretary read a letter from Mr. F. W. Devoe referring to the death of Dr. Lockwood, and also an extract from the *Monmouth County Democrat* on the same subject.

Mr. George William Kosmak read a paper entitled "The Comparative Anatomy of the Vertebrate Skin." This paper was illustrated by very fine enlarged colored diagrams, and by objects under microscopes, as noted below, and is published in this issue of the JOURNAL, p. 42.

OBJECTS EXHIBITED.

1. Human blood, eosin stain, under the one-quarter-inch objective exhibited at the last meeting: by FRANK D. SKEEL.

2. Section of leaf of Syrian Wheat, showing trichomes: by FRANK D. SKEEL.

3. Transverse section of skin of Dog-fish with derm denticles projecting.

4. Transverse section of skin of young Sturgeon with derm denticles dropped.

5. Vertical section of *Necturus*, showing glandular developments.

6. Feather germ of Chick at nine days.

7. Vertical section of human scalp, showing roots of hairs.

Exhibits Nos. 3–7 by GEORGE WILLIAM KOSMAK.

Dr. Bashford Dean stated that one of the most important discoveries in this line announced during the past year was that by Miss Julia C. Platt, professor at Mt. Holyoke Seminary, to the effect that the head cartilage is derived from the ectoderm of the embryo.

MEETING OF FEBRUARY 2D, 1894.

The meeting was held in Hamilton Hall, Columbia College. The President, Mr. Charles S. Shultz, in the chair.

Twenty-eight persons were present.

On motion the routine business of the Society was deferred until the next meeting.

Dr. Alexis A. Julien read a paper entitled "A Silicified Form of a New Species of Fungus in Wood from the Petrified Forest near Cairo, Egypt." This paper was illustrated by numerous excellent photographic lantern views, and by objects under five microscopes, consisting of mineralogical sections, prepared with remarkable carefulness and skill by Mr. T. B. Briggs to exhibit the desired characteristics of the material referred to in the paper.

MEETING OF FEBRUARY 16TH, 1894.

The President, Mr. Charles S. Shultz, in the chair.

Twenty-eight persons present

On motion it was resolved that the proposed amendment of the By-Laws be laid on the table.

On motion it was resolved that a committee of five be appointed by the Chair to report on amendment of the By-Laws. The following persons were so appointed: Messrs. William G. De Witt, Walter H. Mead, Horace W. Calef, Dr. Frank D. Skeel, Dr. Edw. G. Love.

On motion it was resolved that the above committee be instructed that, if the By-Laws are not explicit on this subject, they arrange for the plain statement therein that ladies are eligible to resident membership in the Society.

OBJECTS EXHIBITED.

1. Blood of *Amphiuma*, double stained: by FRANK D. SKEEL.

2. Crystals of monobromide of Naphthalin: by CHARLES S. SHULTZ.

MEETING OF MARCH 2D, 1894.

The President, Mr. Charles S. Shultz, in the chair.

Eighteen persons present.

Mr. Francis R. Wardle was elected a Resident Member of the Society.

OBJECTS EXHIBITED.

1. Transverse section of hair of Whale: by CHARLES S. SHULTZ.

2. Transverse section of hair from tail of Elephant: by CHARLES S. SHULTZ.

3. Hair of Horse with eggs and larva of Bot-fly *in situ:* by CHARLES S. SHULTZ.

4. Polyzoon, *Fredericella*, showing statoblasts *in situ:* by HENRY C. BENNETT.

5. Cuticle of *Equisetum*, polarized: by FRANK D. SKEEL.

6. Photomicrographs: Transverse section of stipe of Fern; Transverse section of petiole of Floating Heart, *Limnanthemum;* "Brush and Comb" of Ant; Scale of Eel; "Tongue" of Cricket; Section of Chalcedony; Crystals of Magnesium Sulphate in balsam; Crystals of Morphia Sulphate in balsam.

Dr. Skeel stated, concerning his exhibit, that the Japanese use the stems of *Equisetum* for polishing wood, and also the cuticle of the same, stripped off and inserted in pieces of bamboo, for nail-files, from one of which his specimen was taken.

Dr. Skeel also referred to the late interesting article by Mr. Wenham in the *English Mechanic* on measuring the aperture of lenses, illustrating his remarks by blackboard diagrams.

MEETING OF MARCH 16TH, 1894.

The President, Mr. Charles S. Shultz, in the chair.

Thirty-one persons present.

Messrs. Charles Du Vivier, George R. Du Vivier, and Mrs. Maria O. Le Brun were elected Resident Members of the Society.

The committee appointed with reference to the death of Dr. Samuel Lockwood reported, and the report was accepted and adopted.

Dr. Carlton C. Curtis read a paper entitled "A Contribution to the History of the Formation of the Lichen Thallus." This paper was illustrated by excellent camera drawings, and by objects under microscopes, as noted below.

On motion the thanks of the Society were tendered Dr. Curtis for the paper so presented.

The Corresponding Secretary presented donations to the Cabinet and for distribution among the members from Mr. K. M. Cunningham, of Mobile, Alabama: 1. Chalk, polished, from Waco, Texas, bank of Brazos River; 2. Polished section of limestone from Austin, Texas; 3. Lignite from Mobile Bay, Alabama; 4. Complex crystalline sand from Whistler, Alabama; 5. Green glass slips for examination of the sand; 6. Silicious bodies, designated "*Phytolitharia.*"

The donations were accompanied by the following communication from Mr. Cunningham, dated March 13th, 1894:

"I forward to the Society a few specimens illustrating some studies in micro-geology, and which I believe possess some interest microscopically.

"1. A prepared specimen illustrative of a portion of the cretaceous area of Texas. It is an indurated form of chalk found by myself outcropping on the eastern bank of the Brazos River, at Waco, Texas, the stratum underlying the town of Waco.

"Chalk is an earthy carbonate of lime, consisting almost entirely of microscopic shells of foraminifera. There are several special forms of chalk—as the soft, friable, and very white chalk of commerce, derived especially from the celebrated chalk cliffs of England; and, again, as comprised in a very extensive area of the cretaceous belt of the Southern States, notably in Tennessee, Mississippi, and Alabama. I have been deputized by the State Geologist to investigate and report upon the chalk area of the latter State. And the interesting results of an examination of chalk strata from some thirty different points in Alabama, enabled me to record in the State Report on the Cretaceous Rocks the occurrence of forty species of foraminifera, representing nineteen genera of the foraminifera of the chalk deposits of the globe. These species were identified through the kindness of Anthony Woodward, Ph.D., of New York City. For this purpose I prepared two slides containing, arranged in lines, some one hundred and twenty-five shells each.

"One face of the specimen of Waco chalk is polished in such manner as to exhibit the sections of the various shells and spicular particles, all of which may be seen under a one-quarter-inch lens. By abrading the chalk with a brush while moist, thousands of the perfect crystalline shells may be isolated and studied in their integrity.

"2. A section of limestone, polished on both sides, showing an exceedingly rich aggregation of microscopic Rotaline shells of one species, which in their transverse sections are concave on both faces, similar to the assumed cross-section of a blood corpuscle. This limestone occurs as a stratified formation, and is quarried at Austin, Texas, for the manufacture of lime, and for constructive and monumental purposes.

"3. A specimen of lignite from the shore of Mobile Bay, two miles south of the city, which throws light on the genesis of the coal formations of the carboniferous period. I have already recorded a comprehensive study of this stratum, which will be referred to in the Report on the Tertiary of Alabama.

"The main feature of interest is that when large slabs of the lignite were removed from the water they were as plastic as potter's clay, but they would also readily split into layers, which exhibit the films of ferns and other vegetable impressions. In drying, this lignite shrinks at least fifty per cent in bulk, but preserves the vegetable impressions, which may be readily seen with a low power.

"This small specimen represents the last phase of coal plant deposition, and belongs just under the superficial or pleistocene strata of the tertiary of Alabama. The stratum from which the specimen was derived was heavily impregnated with ferric sulphide, containing myriads of minute golden-hued spherules of pyrite, isolated in quantity by gravity and solution in water.

"4. Packets of a complex crystalline sand derived from the superficial stratum largely capping the argillaceous strata of

Mobile County. A full analytical study of the same has been made for the Alabama Report on the Tertiary.

"The sand has a greater specific gravity than common silicious sands. By the passage of a small magnet, crystalline grains of magnetite and magnetic spherules may be isolated, and when a portion of the sand is spread on a glass slip, and gently tapped to reject all grains which do not adhere, many perfect crystals of silex will be found, showing minute crystalline inclusions, gaseous or other vacuoles, and the characteristic colors of the true gems when examined by polarized light. The use of the green glass slips accompanying these packets differentiates the angles, edges, apices, gaseous vacuoles, and minute crystalline inclusions of these grains, in beautiful pink or rose-colored hues against an emerald-green ground.

"5. A packet of curious silicious bodies, designated by Dr. Ehrenberg as '*Phytolitharia*,' to each of which he gave a specific name in his 'Micro-Geologie,' as if they possessed the same interest as the diatoms and rhizopods usually associated with them.

"These are examined by spreading a thin layer in a dried state under condensed surface illumination, when the characteristic features of each will be noted. If mounted in balsam the stereoscopic character is lost, as all the cylinders, etc., appear flat and of little interest. The differentiating power of the polariscope is well shown on a balsam-mounted slide of these 'Phytolithariæ.' A few scattering grains of silicious sand and micaceous scales respond to the polarizing power, glowing with prismatic colors, but not one of all the various forms of 'Phytolitharia.' These 'Phytolithariæ' are derived from a stratum of swamp clay at Whistler, Alabama, and also from a stratum of bluish plastic clay containing a long series of plant and animal remains, *i.e.*, diatoms, rhizopods, spongilla spicules, plant capsules, and spores in endless profusion."

OBJECTS EXHIBITED.

1. The Alga as scraped from trees: by CARLTON C. CURTIS.
2. Longitudinal section of young thallus: by CARLTON C. CURTIS.
3. Longitudinal section of sporocarp: by CARLTON C. CURTIS.

4. Longitudinal section of apothecium: by CARLTON C. CURTIS.

5. Section of Agate from basalt, Paterson, N. J.: by J. D. HYATT.

6. Section of Pitch Stone, Isle of Arran, Scotland: by J. D. HYATT.

7. Cinnabarite, cinnabar in chalcedony with native gold: by J. D. HYATT.

8. Transverse section of stem of Poison Ivy, *Rhus toxicodendron:* by J. D. HYATT.

9. Sections through head and thorax of House-Fly: by L. RIEDERER.

10. Hemlock joist, 2×4 inches × 2 feet, from lintel of door of outbuilding thirty-five years old, almost entirely eaten away by our native large black ant, probably *Camponotus herculaneus* L.: by FRANK D. SKEEL.

Mr. Hyatt explained his exhibit of *Rhus toxicodendron* by means of blackboard drawings, showing that this stem, when growing unattached, has the pith in the centre; but when attached to a tree or wall, always has an eccentric growth, the pith lying near the bark on the outer side, and the enlarged rings of growth lying on the inner side, next the object of support, thus indicating that nourishment is derived through the rootlets which cling to the support.

THE MICROSCOPE AND MICROSCOPICAL METHODS. Part I. of The Microscope and Histology. By SIMON HENRY GAGE, Associate Professor of Anatomy, Histology, and Embryology in Cornell University. Fifth edition, rewritten, greatly enlarged, and illustrated by 103 figures in the text. Ithaca, N. Y.: Comstock Publishing Co., 1894. Pp. 165. Price, $1.50.

This work had its origin in the necessities of the class room. As stated in the preface, "the aim has been to produce a book for beginners in microscopy, such as the author himself felt sorely the need of when he began the study." How well this object has been accomplished, during the evolution of fifteen years to this present edition, is demonstrated with great satisfaction to

the reader, as he examines the successive chapters with their thorough, clear, and masterly exposition of the necessary successive steps in the knowledge of the microscope and its applications. The book is one of the best of its kind: a labor-saving implement to the beginner, in the class room or out; and to the amateur, who perhaps for years has been feeling his way and attempting in various directions to invent methods of his own, an unspeakable boon in condensing the experience of a host of workers, and bringing this so conveniently at hand where it can be laid hold of at once, as occasion requires. Prof. Gage is to be congratulated on the able manner in which he has improved and augmented the instruction in this volume.

THE BIOLOGY OF FERNS BY THE COLLODION METHOD. By GEORGE F. ATKINSON, Ph.B., Associate Professor of Cryptogamic Botany in Cornell University. Part I.—Descriptive, with 163 illustrations in the text. Part II.—Methods. New York: Macmillan & Co., 1894. Pp. 134. Price, $2.00.

In seven chapters of Part I. of this work the author, in condensed but lucid and satisfactory manner, conducts the reader through the subject of the biology of ferns under two main subdivisions—the gametophytic phase, or the prothallus, with its archegonia, antheridia, and resulting fertilization; and the sporophytic phase, or that of the popularly known fern proper, from embryo through the examination of stem, root, and frond to the fructification, and occasional sporophytic budding, or production of bulbs. In the eighth and concluding chapter of the same part is a short exposition of the structure of the Ophioglosseæ, introduced, as the author says, because they "present excellent subjects for comparative study." Part II. is an exposition of the technique of the collodion method of infiltration and embedding employed in securing the preparations demonstrating and illustrating the successive steps of Part I. The highest commendation of this collodion method is the statement that it has produced the beautiful and accurate illustrations here displayed. The one hundred and sixty-three illustrations are all original, chiefly by the author; but the delicate and encouraging compliment of accrediting each pupil as the preparator and draughtsman, when he has so furnished an occasional illustration, is exceedingly refreshing in these days of ordinarily free-hand appropriation of everything within reach considered as advantageous for the occasion. The paper, presswork, and beautiful figures illustrating the logically arranged and instructive text of this publication combine to render it in every respect most admirable. The work is intended primarily as a text book, a guide, instructor, and incentive in the class room for those who have before them the coveted prize—"Ph.D." But it also gently and invitingly opens the door of access, in view of many an amateur outside the class room, to a department of examination and discovery among the most fascinating in all the domain of botany.

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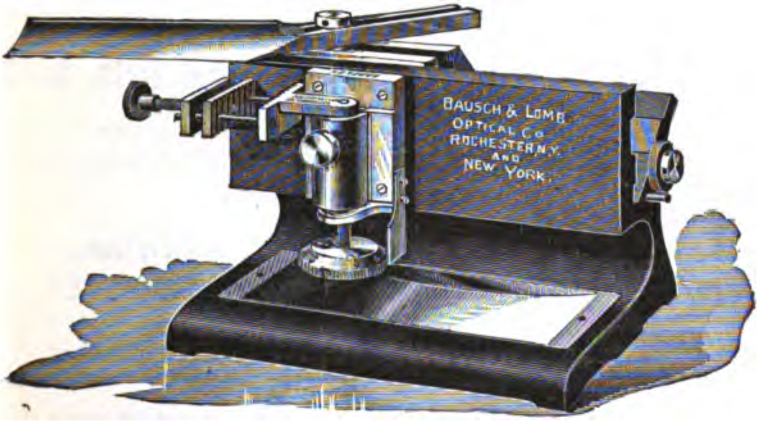

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SEND FOR CATALOGUE.

Vol. X. OCTOBER, 1894. No. 4.

10,412

JOURNAL

OF THE

New-York Microscopical Society

EDITED BY

REV. J. L. ZABRISKIE,

WAVERLEY AVE., FLATBUSH, L. I., N. Y.

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New York:

PUBLISHED FOR THE SOCIETY,

QUARTERLY.

PRESS OF STETTINER, LAMBERT & CO.,
22, 24 & 26 READE STREET.
1894.

[Entered at the Post-Office at New York as second-class matter.]

New-York Microscopical Society.

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JOURNAL
—OF THE—
NEW-YORK MICROSCOPICAL SOCIETY
CONTAINING ITS TRANSACTIONS AND PROCEEDINGS.

PUBLISHED QUARTERLY.

All communications for the JOURNAL, all subscriptions, and all exchanges, should be addressed to the editor, Rev. J. L. Zabriskie, Waverley Avenue, Flatbush, L. I., N. Y.

Terms of Subscription:—In the United States and Canada, One Dollar per annum, beginning with the January number. In Great Britain and Europe, Five Shillings per annum.

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JOURNAL
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VOL. X. OCTOBER, 1894. No. 4.

THE CRETACEOUS FORAMINIFERA OF NEW JERSEY.

PART II. ORIGINAL INVESTIGATIONS AND REMARKS.

BY ANTHONY WOODWARD, PH.D.

(*Presented April 6th*, 1894.)

After a number of years of close and careful study a vast amount of rough material has been worked over. I have succeeded in identifying twenty-six genera and fifty-nine species of Foraminifera from the cretaceous formation of New Jersey. The material examined was in part kindly sent to me by the late Prof. Geo. H. Cook, State Geologist of New Jersey, and collected by Dr. N. L. Britton; it was also received in part from Wm. E. Chase, of Franklin, N. J., and James Walker, of Brooklyn, N. Y., besides many other sources. I spent two days at Mullica Hill, a beautiful Quaker village, collecting marls from the terebratula, gryphæa beds, and the one just above it. From these beds I identified most of the species mentioned in this paper.

The marls from certain localities are very rich in *Nodosaria, Crislettaria,* and *Polymorphina,* especially those from Mullica Hill and the yellow limestone from Timber Creek. My most esteemed friend, the late H. B. Brady, F.R.S., of London, England, aided me greatly by verifying such species as I doubted.

LITUOLIDÆ.

Sub-family TROCHAMMINÆ.

TROCHAMMINA Parker and Jones.

TROCHAMMINA INFLATA Montagu, sp.

Nautilus inflatus Montagu. 1808. Test. Brit. Suppl. 81. pl. xviii. fig. 3.

Rotalina inflata Williamson. 1858. Rec. Foram. Gt. Brit. 50. pl. iv. figs. 93, 94.

Rotalina (*Trochammina*) *inflata* Parker and Jones. 1859. Ann. and Mag. Nat. Hist. ser. 3. iv. 347. fig. F.

Trochammina inflata. Carpenter. 1862. Introd. Foram. 141. pl. xi. fig. 5.

Trochammina squamata, var. *inflata* Parker and Jones. 1862. Introd. Foram. Appendix. 310.

Trochammina inflata Brady. 1865. Nat. Hist. Trans. Northd. and Durham. i. 95.

Trochammina inflata (?) Tate and Blake. 1876. Yorkshire Lias.452. pl. xvii. fig 18.

Trochammina inflata Brady. 1884. Report on Foram. H. M. S. Challenger. Zool. ix. 338. pl. xli. fig. 4. a–c.

Trochammina inflata Woodward and Thomas. 1893. Final Report Geol. Nat. Hist. Survey Minn. iii. 28. pl. D. fig. 31.

"Test free; trochoid or convex, depressed, rotaliform; consisting of about three convolutions, the outermost of which is formed of five or six very ventricose segments with deeply excavated septal lines. Inferior face somewhat concave, with sunken umbilicus; peripheral margin lobulated. Aperture small, arched; situate on the inferior side of the final segment, close to previous convolution, a little within the periphery. Color pale brown, the small primary segments much darker than the rest."—Brady, loc. cit.

Locality. Stratton's marl pit, near Mullica Hill, in the shell layers of the green marl. Rare. Timber Creek, yellow limestone. Rare.

WEBBINA d'Orbigny.

WEBBINA RUGOSA d'Orbigny.

Webbina rugosa d'Orbigny. 1839. Foram. d. Iles Canaries. 125. pl. i. figs. 16–18.

Webbina rugosa d'Orbigny. 1846. Foram. Foss. Vien. 74. pl. xxi. figs. 11, 12.

Test depressed, elongate, twisted, white, above convex rugose, below complanate, with three pyriform chambers ; spinose, round aperture, peristome elevated, enlarged.

Locality. Timber Creek, in the yellow limestone. Rare. Also in the teredo bed. Rare.

TEXTULARIDÆ.

Sub-family TEXTULARINÆ.

TEXTULARIA Defrance.

TEXTULARIA AGGLUTINANS d'Orbigny.

Textularia agglutinans d'Orbigny. 1839. Foram. Cuba 144. pl. i. figs. 17, 18, 32–34.

Textularia agglutinans Seguenza. 1862. Atti dell' Accad. Gisenia. ser. 2. xviii. 112. pl. ii. fig. 4.

Plecanium sturi Karrer. 1864. Sitzungsb. d. K. Ak. Wiss. Wien. i. 704. pl. i. fig. 1.

Textularia agglutinans Parker and Jones. 1865. Phil. Trans. clv. 369. pl. xv. fig. 21.

Plecanium agglutinans Reuss. 1869. Sitzungsb. d. K. Ak. Wiss. Wien. lix. 452. pl. i. figs. 1, 2.

Textularia agglutinans G. M. Dawson. 1875. Report Geol. Resources 49th Parallel, British N. A. Boundary Comm. 79.

Textilaria agglutinans Moebius. 1880. Foram. von Mauritius. 93. pl. ix. figs. 1–8.

Textularia agglutinans Brady. 1884. Report on Foram. H. M. S. Challenger. Zool. ix. 363. pl. xliii. figs. 1–3. vars. figs. 4, 12.

Textularia agglutinans Woodward and Thomas. 1885. Geol. Nat. Hist. Survey Minn. 13th Ann. Report. 167. pl. iii. figs. 6, 7.

Textularia agglutinans Tyrrell. 1890. Trans. Roy. Soc. Can. vii. 114.

Test elongate, conical, rugose, agglutinous (from grains of sand), white, laterally convex, posteriorly cuneate, segments large, the last convex, aperture semi-lunate.

Locality. Timber Creek, in the yellow limestone. Rare.

TEXTULARIA CARINATA d'Orbigny.

Textularia carinata d'Orbigny. 1826. Ann. Sci. Nat. vii. 263. No. 23.

Textularia carinata d'Orbigny. 1846. Foram. Foss. Vien. 247. pl. xiv. figs. 32–34.

Textularia lacera Reuss. 1851. Zeitschr. d. deutsch. geol. Gesell. iii. 84. pl. vi. figs. 52, 53.

Textularia attenuata Reuss. 1851. Zeitschr. d. deutsch. geol. Gesell. iii. 84. pl. vi. fig. 54.

Textilaria carinata, and *T. carinata,* var. *attenuata* Reuss. 1870. Sitzungsb. d. K. Ak. Wiss. Wien. lxii. 489. No. 1. Schlicht. 1870. Foram. Pietzpuhl. pl. xxxiii. figs. 1–4, 8, 9.

Textilaria carinata Hantken. 1875. Mitth Jahrb. d. k. ung. geol. Anst. iv. 66. pl. vii. fig. 8.

Textularia carinata Brady. 1884. Report on Foram. H. M. S. Challenger. Zool. ix. 360. pl. xlii. figs. 15, 16.

Textularia carinata Woodward and Thomas. 1893. Final Report Geol. Nat. Hist. Survey Minn. iii. 30. pl. C fig. 11.

Test cuneiform, lingulata, convex, punctate, anteriorly dilate, truncate, posteriorly obtuse acuminate, laterally carinate, acute, lamellose ; foramina narrow, oblique, arcuate, marginate.

Locality. Stratton's marl pit, near Mullica Hill, in the shell layers of the green marl. Quite rare.

TEXTULARIA GRAMEN d'Orbigny.

Textularia gramen d'Orbigny. 1846. Foram. Foss. Vien. 248. pl. xv. figs. 4, 6.

Textularia gramen Brady. 1884. Report on Foram. H. M. S. Challenger. Zool. ix. 365. pl. xliii. figs. 9, 10.

Test ovate-lingulate, compressed, punctate, anteriorly dilate, rotund, posteriorly obtuse, laterally angular, subcarinate; with wide chambers, obliquely transverse, arcuate, somewhat convex.

Locality. Timber Creek, in the yellow limestone. Not common.

TEXTULARIA TURRIS d'Orbigny.

Textularia turris d'Orbigny. 1840. Mém. Soc. géol. France. iv. 46. pl. iv. figs. 27, 28.

Textularia turris Parker and Jones. 1863. Ann. and Mag. Nat. Hist. ser. 3. xi. 97.

Textularia turris Brady. 1884. Report on Foram. H. M. S. Challenger. Zool. ix. 366. pl. xliv. figs. 4, 5.

Textularia turris Woodward and Thomas. 1885. Geol. Nat. Hist. Survey Minn. 13th Ann. Report. 167. pl. iii. fig. 8.

Textularia turris (?) Tyrrell. 1890. Trans. Roy. Soc. Can. vii. 114.

Textularia turris Woodward and Thomas. 1893. Final Report Geol. Nat. Hist. Survey Minn. iii. 30. pl. C. figs. 9, 10.

Test elongate, conical, turriculate, rugose, non-compressed, posteriorly acuminate, anteriorly truncate; chambers complanate.

Locality. Timber Creek, in the yellow limestone and gryphæa bed. Not abundant.

TEXTULARIA SAGITTULA Defrance.

"*Polymorphum sagittula*" Soldani. 1791. Testaceographia. i. 120. pl. cxxxiii. fig. T.

Textularia sagittula Defrance. 1824. Dict. Sci. Not. xxxii. 177; liii. 344; Atlas Conch. pl. xiii. fig. 5.

Textularia sagittula Blainville. 1825. Malacologie. 370. pl. v. fig. 5.

Textularia sagittula d'Orbigny. 1826. Ann. Sci. Nat. vii. 263. No. 20.

Textularia saulcyana d'Orbigny. 1839. Foram. Cuba. 137. pl. i. figs. 21, 22.

Textularia cuneiformis d'Orbigny. 1839. Foram. Cuba. 138. pl. i. figs. 37, 38.

Textularia nussdorfensis d'Orbigny. 1846. Foram. Foss. Vien. 243. pl. xiv. figs. 17–19.

Textularia bronniana d'Orbigny. 1846. Foram. Foss. Vien. 244. pl. xiv. figs. 20–22.

Textularia deperdita d'Orbigny. 1846. Foram. Foss. Vien. 244. pl. xiv. figs. 23–25.

Textularia prælonga Czjzek. 1847. Haidinger's Naturw. Abhandl. ii. 149. pl. xiii figs. 28–30.

Textularia acuta Reuss. 1849. Denkschr. d. K. Akad. Wiss. Wien. i. 381. pl. xlix. fig. 1.

Textularia cuneiformis Williamson. 1858. Rec. Foram. Gt. Br. 75. pl. vi. figs. 158, 159.

Textularia agglutinans, var. *sagittula* Parker and Jones. 1865. Phil. Trans. clv. 369 pl. xvii. fig. 77. a, b.

Textularia sagittula Brady. 1884. Report on Foram H. M. S. Challenger. Zool. ix. 361. pl. xlii. figs. 17, 18.

Test elongate, somewhat compressed, very rugose, posteriorly acuminate-carinate, anteriorly subcylindrical-truncate; with narrow chambers, arcuate, limbate above, aperture linear.

Locality. New Egypt, in the green marl. Rare. Timber Creek, in the gryphæa bed. Quite rare.

SPIROPLECTA Ehrenberg.

SPIROPLECTA AMERICANA Ehrenberg.

Spiroplecta americana Ehrenberg. 1854. Mikrogeologie. pl. xxxii. I. figs. 13, 14; II. fig. 25.

Spiroplecta americana Brady. 1884. Report on Foram. H. M. S. Challenger. Zool. ix. 376. pl. xlv. fig. 24. a, b.

Spiroplecta americana Woodward and Thomas. 1885. Geol. Nat. Hist. Survey Minn. 13th Ann. Report. 168 pl. iii. fig. 9.

Spiroplecta americana Woodward and Thomas. 1893. Final Report Geol. Nat. Hist. Survey Minn. iii. 31. pl. C. figs. 12, 13, 14.

"The test is usually much compressed, and widens rapidly towards the distal end; the lateral edges are thin and slightly lobulated, the chambers somewhat inflated, and the septal lines correspondingly depressed on the exterior; the walls are thin and smooth."—Brady, loc. cit.

Locality. Timber Creek, in the gryphæa bed. Rare.

GAUDRYINA d'Orbigny.

GAUDRYINA PUPOIDES d'Orbigny.

Gaudryina pupoides d'Orbigny. 1840. Mém. Soc. géol. France. iv. 44. pl. iv. figs. 22–24.

Gaudryina pupoides d'Orbigny. 1846. Foram. Foss. Vien. 197. pl. xxi. figs. 34–36.

Gaudryina subglabra Gümbel. 1868. Abh. d. K. bayer. Akad. Wiss. II. cl. x. 602. pl. i. fig. 4.

Gaudryina pupoides Brady. 1884. Report on Foram. H. M. S. Challenger. Zool. ix. 378. pl. xlvi. figs. 1–4.

Gaudryina pupoides Woodward and Thomas. 1885. Geol. Nat. Hist. Survey Minn. 13th Ann. Report. 168. pl. iii. fig. 10.

Gaudryina pupoides Woodward and Thomas. 1893. Final Report Geol. Nat. Hist. Survey Minn. iii. 31. pl. C. figs. 15, 16.

Test elongated, rugose, (young) rotund, (adult) compressed; spire obtuse; chambers convex, (young) narrow, transversely oblong, (adult) globular.

Locality. Stratton's marl pit, near Mullica Hill, in the shell layers of the green marl. Quite rare.

VERNEUILINA d'Orbigny.

VERNEUILINA TRIQUETRA Münster, sp.

Textularia triquetra Münster. 1838 (in Römer's paper). Neues Jahrb. für Minn. etc. 384. pl. iii. fig. 19.

Textularia triquetra Reuss. 1845. Verstein. Böhm. Kreid. pt. 1. 39. pl. xiii. fig. 77.

Textularia atlantica Bailey. 1851. Smithsonian Contrib. ii. art. 3. 12. figs. 38–42.

Textularia (*Verneuilina*) *triquetra* Parker and Jones. 1863. Ann. and Mag. Nat. Hist. ser. 3. xi. 92.

Verneuilina triquetra Brady. 1884. Report on Foram. H. M. S. Challenger. Zool. ix. 383. pl. xlvii. figs. 18–20.

Test carinate, acutely triangular with a curved lateral side (or face) in the centre, so that a cross section presents the appearance of a triangle, with somewhat concave sides. On every side seven to eight very low, somewhat rough chambers, whose sutures are slightly elevated, the uppermost chamber somewhat arched; aperture a slit on the inner side of the last chamber, parallel to a side face of the pyramid.

Locality. Stratton's marl pit, near Mullica Hill, in the shell layers of the green marl. Very abundant. Timber Creek, in the gryphæa bed. Abundant.

TRITAXIA Reuss.

TRITAXIA TRICARINATA Reuss.

Textularia tricarinata Reuss. 1845. Verstein. Böhm. Kreid. i. 39. pl. viii. fig. 60.

Verneuilina dubia Reuss. 1850. Haidinger's Naturw. Abhandl. iv. 40. pl. iv. fig. 3.

Tritaxia tricarinata Reuss. 1860. Sitzungsb. d. K. Ak. Wiss. Wien. xl. 228. pl. xii. figs. 1, 2.

Tritaxia tricarinata Brady. 1884. Report on Foram. H. M. S. Challenger. Zool. ix. 389. pl. xlix. figs. 8, 9.

Test very rough, elongate elliptical, triangular, tricarinate, on either side attenuate, walls somewhat concave, sutures obsolete, aperture small, subelliptical.

Locality. Timber Creek, in the yellow limestone. Quite rare.

CLAVULINA d'Orbigny.

CLAVULINA COMMUNIS d'Orbigny.

Clavulina communis d'Orbigny. 1826. Ann. Sci. Nat. vii. 268. No. 4.

Clavulina communis d'Orbigny. 1846. Foram. Foss. Vien. 196. pl. xii. figs. 1, 2.

Verneuilina communis Jones and Parker. 1860. Quart. Journ. Geol. Soc. xvi. 303. No. 82.

Clavulina communis Fischer. 1870. Actes Soc. Linn. Bordeaux. xxvii. 393. No. 33.

Verneuilina communis Van den Broeck. 1876. Ann. Soc. Belg. Micr. ii. 136. pl. iii. fig. 14.

Clavulina communis Brady. 1884. Report on Foram. H. M. S. Challenger. Zool. ix. 394. pl. xlviii. figs. 1–13.

Test elongate, clavate, rugose, cylindrical anteriorly, posteriorly inflated, obtuse, convex chambers, terminal one anteriorly subacuminate.

Locality. Stratton's marl pit, near Mullica Hill, in the shell layers of the green marl. Common. Timber Creek, teredo bed. Abundant.

Sub-Family BULIMINÆ.

BULIMINA d'Orbigny.

BULIMINA PUPOIDES d'Orbigny.

Bulimina pupoides d'Orbigny. 1846. Foram. Foss. Vien. 185. pl. xi. figs. 11, 12.

Bulimina pupoides Williamson. 1858. Rec. Foram. Gt. Br. 62. pl. v. figs. 124, 125.

Bulimina tortilis Reuss. 1861. Sitzungsb. d. K. Akad. Wiss. Wien. xliv. 338. pl. viii. fig. 3.

Bulimina presli, var. *pupoides* Parker and Jones. 1862. Introd. Foram. Appendix. 311.

Bulimina pupoides Terrigi. 1880. Atti dell' Accad. Pont. xxxiii. 193. pl. ii. figs. 30–34.

Bulimina pupoides Brady. 1884. Report on Foram. H. M. S. Challenger. Zool. ix. 400, 401. pl. l. fig. 15. a, b.

Bulimina pupoides Woodward and Thomas. 1885. 13th Ann. Report Geol. Nat. Hist. Survey Minn. 169. pl. iii. fig. 11.

Bulimina pupoides Tyrrell. 1890. Trans. Roy. Soc. Can. 114.

Bulimina pupoides Woodward and Thomas. 1893. Final Report Geol. Nat. Hist. Survey Minn. iii. 32. pl. C. figs. 20–24.

Test oblong; obtuse, especially at the inferior lateral surface; composed of numerous segments, arranged in an indistinct spiral, and exhibiting a tendency to form three oblique vertical rows; segments remarkably ventricose and prominent; the anterior one usually more oblong than the rest, from its anterior part not being embraced, as all the preceding ones, by the next segment. Septal plane convex; semilunar. Septal orifice single, placed near the umbilical border of the septal plane, and usually characterized by a curious obliquity at its part, owing to the two lips of the orifice not meeting at their umbilical extremities, but passing one behind the other.

Locality. Stratton's marl pit, near Mullica Hill, in the shell layers of the green marl. Rare. Fragments only.

BULIMINA PYRULA d'Orbigny.

Bulimina caudigera d'Orbigny. 1826. Ann. Sci. Nat. vii. 270. No. 16; Modèle No. 68.

Bulimina ovula d'Orbigny. 1839. Foram. Amér. Mérid. 51. pl. i. figs. 10, 11.

Bulimina pyrula d'Orbigny. 1846. Foram. Foss. Vien. 184. pl. xi. figs. 9, 10.

Bulimina auriculata Bailey. 1851. Smithsonian Contrib. ii. Art. 3. 12. figs. 25–27.

Bulimina turgida Id. Ibid. 12. figs. 28–31.

Guttulina prunella Costa. 1856. Atti dell' Accad. Pont. vii. 274. pl. xiii. figs. 32, 33, 37, 38.

Guttulina mutabilis Id. Ibid. 275. pl. xviii. figs. 1–3.

Bulimina auriculata Dawson. 1859. Canad. Nat. iv. 31. fig. 22.

Bulimina auriculata Id. 1860. Can. Nat. and Geol. v. 190.

Bulimina presli, var. *pyrula* Parker and Jones. 1865. Phil. Trans. clv. 372. pl. xv. figs. 8, 9.

Bulimina pyrula Brady. 1884. Report on Foram. H. M. S. Challenger. Zool. ix. 399. pl. l. figs. 7–10.

Bulimina pyrula Whiteaves. 1887. Trans. Roy. Soc.Can. iv. 114.

Test ovate, anteriorly and posteriorly acuminate, smooth, short spire, obtuse ; with three narrow convolutions ; with three somewhat convex segments.

Locality. Timber Creek, teredo bed. Rare.

PLEUROSTOMELLA Reuss.

PLEUROSTOMELLA SUBNODOSA Reuss.

Nodosaria nodosa (pars) Reuss. 1845. Verstein. Böhm. Kreid. pt. 1. 28. pl. xiii. fig. 22 (*fide* Reuss).

Dentalina subnodosa (pars) Id. 1850. Haidinger's Naturw. Abhandl. iv. 24. pl. i. fig. 9 (*fide* Reuss).

Pleurostomella subnodosa Id. 1860. Sitzungsb. d. K. Ak. Wiss. Wien. xl. 204. pl. viii. fig. 2. a, b.

Pleurostomella subnodosa Marsson. 1878. Mittheil. Naturw. Vereine Neu-Vorpom. u. Rügen. x. 133.

Pleurostomella subnodosa Brady. 1884. Report on Foram. H. M. S. Challenger. Zool. ix. 412. pl. lii. figs. 12, 13.

Test elongated, nearly straight ; chambers quite regularly increasing, slightly convex, the last one the largest, convex, shortly acute ; the first chamber smallest, rather obtuse ; aperture naked.

Locality. Timber Creek, gryphæa bed. Rare.

BOLIVINA d'Orbigny.

BOLIVINA PUNCTATA d'Orbigny.

Bolivina punctata d'Orbigny. 1839. Foram. Amér. Mérid. 61. pl. viii. figs. 10–12.

Bolivina antiqua d'Orbigny. 1846. Foram. Foss. Vien. 240. pl. xiv. figs. 11–13.

Grammostomum polystigma Ehrenberg. 1854. Mikrogeologie. pl. xix. fig. 84.

Grammostomum caloglossa Ehrenberg. 1854. Mikrogeologie. pl. xxv. figs. 17, 18.

Bolivina punctata Brady. 1864. Trans. Linn. Soc. Lond. xxiv. 468. pl. xlviii. fig. 9. a, b.

Bulimina presli, var. (*Bolivina*) *punctata* Parker and Jones. 1865. Phil. Trans. clv. 376. pl. xviii. fig. 74.

Bolivina elongata Hantken. 1875. Mittheil. Jahrb. d. K. ung. geol. Anstalt. iv. 65. pl. vii. fig. 14.

Bolivina antiqua Terrigi. 1880. Atti dell' Accad. Pont. xxxiii. 196. pl. ii. fig. 40.

Bolivina punctata Moebius. 1880. Foram. von Mauritius. 94. pl. ix. figs. 9, 10.

Bulimina (*Bolivina*) *punctata* Goës. 1882. Kongl. Sv. Vet. Akad. xxix. 69. pl. iv. figs. 114–126.

Bolivina punctata Brady. 1884. Report on Foram. H. M. S. Challenger. Zool. ix. 417. pl. lii. figs. 18, 19.

Bolivina punctata Woodward and Thomas. 1885. Geol. Nat. Hist. Survey Minn. 13th Ann. Report. 169. pl. iii. fig. 12.

Bolivina punctata Woodward and Thomas. 1893. Final Report Geol. Nat. Hist. Survey Minn. iii. 34. pl. C. figs. 27, 28.

Test elongated, compressed, conical, obtuse anteriorly, acuminate posteriorly, white, punctate, sub-carinate on sides; with numerous oblique undulate segments, the last obtuse; aperture simple.

Locality. Lower marl bed, light gray, sandy marl at Bruere's pits, Crosswick's Creek. Rare.

LAGENIDÆ.

Sub-family LAGENINÆ.

LAGENA Walker and Boys.

LAGENA GLOBOSA Montagu, sp.

"*Serpula* (*Lagena*) *lævis globosa*" Walker and Boys. 1784. Test. Min. 3. pl. i. fig. 8.

"*Ossicula madreporaria*" Soldani. 1795. Testaceographia. i. pt. 3. 245. pl. clxxii. figs. B, C, etc.

Vermiculum globosum Montagu. 1803. Test. Brit. 523.

Oolina inornata d'Orbigny. 1839. Foram. Amér. Mérid. 21. pl. v. fig 13.

Oolina simplex Reuss. 1851. Haidinger's Naturw. Abhandl. iv. 22. pl. i. fig. 2.

Miliola sphæroidea Ehrenberg. 1854. Mikrogeologie. pl. xxxiii. fig. 1.

Cenchridium oliva Ehrenberg. 1854. Mikrogeologie. pl. xxiv. figs. 3, 4.

Phialina oviformis Costa. 1856. Atti dell' Accad. Pont. vii. 123. pl. xi. figs. 8, 9.

Fissurina obtusa Egger. 1857. Neues Jahrb. für Min. etc. 270. pl. v. figs. 16–19.

Entosolenia globosa Parker and Jones. 1857. Ann. and Mag. Nat. Hist. ser. 2. xix. 278. pl. xi. figs. 25–29.

Entosolenia globosa Williamson. 1858. Rec. Foram. Gt. Br. 8. pl. i. figs. 15, 16.

Fissurina solida Seguenza. 1862. Foram. Monotal. Mess. 56. pl. i. fig. 42.

Entosolenia globosa Dawson. 1859. Can. Nat. and Geol. iv. 28. figs. 4, 5.

Entosolenia globosa Dawson. 1862. Proc. Portland Soc. Nat. Hist. i. 83.

Fissurina rugosula Seguenza. 1862. Foram. Monotal. Mess. 56. pl. i. fig. 43.

Lagena sulcata, var. (*Entosolenia*) *globosa* Parker and Jones. 1865. Phil. Trans. clv. 348. pl. xiii. fig. 37; pl. xvi. fig. 10.

Lagena globosa Jones, Parker, and Brady. 1866. Monograph of the Foram. of the Crag. 32. pl. i. fig. 32.

Cenchridium aargovense Kübler. 1870. Foram. Schweiz. Jura. 13. pl. ii. I. fig. 2.

Lagena parkinsoni Kübler. 1870. Foram. Schweiz. Jura. 17. pl. ii. III. fig. 1.

Lagena minutissima Kübler. 1870. Foram. Schweiz. Jura. 19, 21. pl. ii. IV. fig. 1.

Lagenulina globosa Terquem. 1876. Anim. sur la Plage de Dunkerque. fasc. 2. 67. pl. vii. figs. 3, 4.

Lagena globosa Brady. 1884. Report on Foram. H. M. S. Challenger. Zool. ix. 452. pl. lvi. figs. 1, 2, 3.

Test ovato-globose, sometimes projecting slightly at the apex; smooth, and without surface-marking. Tube entosolenian. Walls thin and hyaline.

Locality. Stratton's marl pit, near Mullica Hill, in the shell layers of the green marl. Rare.

Sub-family NODOSARINÆ.

NODOSARIA Lamarck.

NODOSARIA (D.) COMMUNIS d'Orbigny.

Nodosaria (*Dentalina*) *communis* (?) d'Orbigny. 1826. Ann. Sci. Nat. vii. 254. No. 35.

Dentalina communis d'Orbigny. 1840. Mém. Soc. géol. France, iv. 13. pl. i. fig. 4.

Nodosaria linearis Römer. 1842. Verst. Nordd. Kreidegeb. 95. pl. xv. fig. 5.

Nodosaria communis Reuss. 1845. Verstein. Böhm. Kreid. pt. i. 28. pl. xii. fig. 21.

Nodosaria legumen Id. Ibid. 28. pl. xiii. figs. 23, 24.

Dentalina inornata d'Orbigny. 1846. Foram. Foss. Vien. 44. pl. i. figs. 50, 51.

Dentalina badenensis Id. Ibid. 44. figs. 48, 49.

Dentalina ferstliana Czjzek. 1847. Haidinger's Naturw. Abhandl. ii. 140. pl. xii. figs. 10–13.

Dentalina intermedia Corn. 1848. Nouv. Foss. Microsc. Cret.; Mém. Soc. géol. France. ser. 2. iii. 251. pl. i. fig. 20.

Dentalina gracilis Alth. 1849. Umgeb. Lemb.; Haidinger's Naturw. Abhandl. iii. (2) 269. pl. xiii. fig. 27.

Dentalina mutabilis Bailey. 1850. Smithsonian Contrib. ii. Art. 3. 10. fig. 7.

Marginulina ensis Reuss. 1851. Haid. Nat. Abhandl. iv. p. ii. figs. 16–18.

Dentalina haueri Neugeboren. 1856. Denkschr. d. K. Akad. Wiss. xii. 81. pl. iii. fig. 12.

Dentalina orbignyana Id. Ibid. pl. iii. figs. 1–3.

Dentalina subarcuata Williamson. 1858. Rec. Foram. Gt. Brit. 18. pl. ii. figs. 40, 41.

Dentalina torta Terquem. 1858. Foram. du Lias. 1re mém. 599. pl. ii. fig. 6.

Dentalina vetusta Terquem. Ibid. 598. pl. ii. 4.

Dentalina legumen Reuss. 1860. Sitzungsb. d. K. Akad. Wiss. Wien. xl. 187. pl. iii. fig. 5.

Dentalina intermedia Id. Ibid. 186. pl. ii. fig. 8.

Dentalina communis Id. Ibid. 186.

Dentalina colligata Reuss. 1861. Sitzungsb. d. K. Akad. Wiss. Wien. xliv. 334. pl. vii. fig. 4.

Dentalina deflexa Reuss. 1862. Sitzungsb. d. K. Akad. Wiss. Wien. xlvi. 43. pl. ii. fig. 19.

Dentalina inornata Id. 1863. Ibid. xlviii. 45. pl. ii. fig. 18.

Dentalina boettcheri Id Ibid. 44. pl. ii. fig. 17.

Dentalina æqualis Karrer. 1865. Foram. Grünsandstein. N. Zeeland; Novara Reise. geol. ii. 74. pl. xvi. fig. 1.

Dentalina communis Jones, Parker, and Brady. 1866. Monograph of the Foram. of the Crag. 58. pl. i fig. 13–18, 20; pl. iv. fig. 10.

Marginulina ensis Reuss. 1861. Sitzungsb. d. K. Akad. Wiss. Wien. xliv. 335.

Nodosaria neugeboreni Schwager. 1866. Novara Exped. geol. ii. 232. pl. vi. fig. 67.

Nodosaria gracilescens Id. Ibid. 234. pl. vi. fig. 70.

Dentalina intorta Terquem. 1870. Foram. du Syst. Oolith. 3ième mém. 262. pl. xxvii. figs. 26–34.

Dentulina budensis Hantken. 1875. Mittheil. Jahrb. d. K. ung. geol. Anstalt. iv. 34. pl. iii. fig. 12.

Nodosaria (*D.*) *communis* Brady. 1884. Report on Foram. H. M. S. Challenger. Zool. ix. 504. pl. lxii. figs. 19–22.

Test elongated, arched, smooth; posteriorly acuminate, caudate; numerous chambers, oblique, last very convex, acuminate, first convex; sutures subcomplanate; very small aperture, radiate.

Locality. Stratton's marl pit, near Mullica Hill, in the shell layers of the green marl. Not abundant. New Egypt, green marl. Fragments. Lower marl bed, gray sandy marl at Bruere's pits, Crosswick's Creek. Fragments. Timber Creek, in the yellow limestone. Fragments. Teredo bed. Quite abundant. Gryphæa bed. Not rare.

NODOSARIA (D.) FILIFORMIS d'Orbigny.

"*Orthoceratia filiformia aut capillaria*" Soldani. 1798. Testaceographia. ii. 35. pl. x. fig. e.

Nodosaria filiformis d'Orbigny. 1826. Ann. Sci. Nat. vii. 253. No. 14.

Dentalina acutissima d'Orbigny. 1839. Foram. Amér. Mérid. 23. pl. iii. fig. 15.

Dentalina acuta Id. Ibid. fig. 16.

Dentalina gracilis Id. 1840. Mém. Soc. géol. France. iv. 14. pl. i. fig. 5.

Dentalina elegans Id. 1846. Foram. Foss. Vien. 45. pl. i. figs. 52–56.

Dentalina reussi Neugeboren. 1856. Denkschr. d. K. Akad. Wiss. Wien. xii. 85. pl. iii. figs. 6, 7.

Dentalina prælonga Costa. 1856. Atti dell' Accad. Pont. vii. 163. pl. xii. fig. 21.

Dentalina vetustissima Terquem. 1858. Foram. du Lias. 1$^{\text{ière}}$ mém. 600. pl. ii. fig. 8.

Dentalina baccata Id. Ibid. 601. pl. ii. fig. 9.

Dentalina pseudomonile Id. Ibid. 606. pl. ii. fig. 18.

Dentalina gracilis Reuss. 1861. Sitzungsb. d. K. Akad. Wiss. Wien. xliv. 334.

Nodosaria elegans Schwager. 1866. Novara Exped. géol. Theil ii. 233. pl. vi. fig. 68.

Dentalina filiformis Parker, Jones, and Brady. 1871. Ann. and Mag. Nat. Hist. ser. 4. viii. 156. pl. ix. fig. 48.

Nodosaria (*D.*) *filiformis* Brady. 1884. Report on Foram. H. M. S. Challenger. Zool. ix. 500. pl. lxiii. figs. 3–5.

Test elongate, arcuate, smooth, shining white, anteriorly obtuse, posteriorly acuminate, very acute, with numerous chambers, laterally semi-distinct; aperture round simple.

Locality. Stratton's marl pit, near Mullica Hill, in the shell layers of the green marl. Rare. Timber Creek, in the yellow limestone. Fragments only. Teredo bed. Rare.

NODOSARIA OBLIQUA Linné, sp.

"*Orthoceras minimum,*" etc. Gaultieri. 1742. Index Test. pl. xix. fig. N.

Nautilus obliquus Linné. 1767. Syst. Nat. 12th ed. 1163. 281; 1788. Ibid. 13th (Gmelin's) ed. 3372. No. 14.

Nautilus jugosus Montagu. 1803. Test. Brit. 198 pl. xiv. fig. 4.

Orthocera obliqua Lamarck. 1822. Anim. sans Vert. vii 594. No. 4.

Nodosaria sulcata Nilsson. 1827. Petrif. Suec. 8. pl. ix. fig. 19.

Nodosaria elegans Roemer. 1838. Neues Jahrb. für Min. etc. 382. pl. iii. fig. 1.

Dentalina bifurcata Reuss. 1849. Denkschr. d. K. Akad. Wiss. Wien. i. 367. pl. xlvi. fig. 10.

Dentalina primæva d'Orbigny. 1850. Prod. Paléont. i. 242. No. 260.

Dentalina kingii Jones. 1850. King's Monogr. Permian Foss. 17. pl. vi. figs. 2, 3.

Dentalina steenstrupi Reuss. 1855. Zeitschr. d. deutsch. geol. Gesellsch. vii. 268. pl. viii. fig. 14, a.

Dentalina sulcata Id. Ibid. 269. pl. viii. fig 14, b.

Dentalina baltica Id. Ibid. 269. pl. viii. fig. 15.

Dentalina bifurcata Costa. 1856. Atti dell' Accad. Pont. vii. 162. pl. xii. fig. 27.

Nodosaria mutabilis Id. Ibid. 150. pl. xiii. fig. 1.

Nodosaria siphunculoides Costa. 1857. Mém. Accad. Sci. Nap. ii. 135. pl. i. fig. 27.

Nodosaria (*Dentalina*) *obliqua* Parker and Jones. 1859. Ann. and Mag. Nat. Hist. ser. 3. iii. 482.

Dentalina pulchra Gabb. 1860. Journ. Acad Nat. Sci. ser. 2. iv. 402, 403. pl. lxix. figs. 40, 41.

Dentalina steenstrupi Reuss. 1861. Sitzungsb. d. K. Akad. d. Wiss. xliv. 326.

Dentalina confluens Reuss. Id. Ibid. 335. pl. vii. fig. 5.

Nodosaria siphunculoides Costa. 1857. Foram. Foss. Marne Terziar Messina. 9. pl. i. fig. 27.

Dentalina lineata Reuss. 1864. Sitzungsb. d. K. Akad. d. Wiss. l. 22. pl. iv. fig. 11.

Dentalina schwarzii Karrer. 1864. Sitzungsb. d. K. Akad. d. Wiss. l. 15. pl. i. fig. 5.

Dentalina obliqua Jones, Parker, and Brady. 1866. Monograph of the Foram. of the Crag. 54. pl. i. fig. 9.

Nodosaria obliqua Brady. 1884. Report on Foram. H. M. S. Challenger. Zool. ix. 513. pl. lxiv. figs. 20–22.

Nodosaria obliqua Meyer. 1886. Bull. Geol. Survey Ala. 85. pl. i. fig. 31.

Test elongated, arcuate, tapering; composed of numerous (six to fifteen) chambers, which are subcylindrical and more or less ventricose, with the septal lines generally constricted, and the surface covered with riblets, varying in number and size in different specimens.

Locality. Stratton's marl pit, near Mullica Hill, in the shell layers of the green marl. Very common. Timber Creek, teredo bed. Not abundant. Near Harrisonville, middle bed, associated with echinoderms. Common.

This is the species that Gabb speaks of finding. and described as a new species *Dentalina pulchra*, from the marl near Mullica Hill. Also *N. sulcata* of Nilsson, who H. v. Credner mentions in Die Kreide von New Jersey d. d. geol. Ges. xiii. 1870, as occurring common in the bryozoan bed at Brownville and Turtle Hill.

NODOSARIA RADICULA Linné, sp.

"*Cornu Hammonis erectum*" Plancus. 1739. Conch. Min. 14. pl. i. fig. 5.

Nautilus radicula Linné. 1767. Syst. Nat. 12th ed. 1164. 285; 1788. Ibid. 13th (Gmelin's) ed. i. pt. 6. 3373. No. 18.

Nautilus radicula Montagu. 1803. Test. Brit. 197. pl. vi. fig. 4.

Nodosaria radicula d'Orbigny. 1826. Ann Sci. Nat. vii. 252. No. 3; Modèle No. 1.

Nodosaria geinitziana Neugeboren. 1852. Verhandl. u. Mitth. siebenb. Vereins f. Nat. iii. 37. pl. i. fig. 1.

Nodosaria glandulinoides Id. Ibid. 37. pl. i. fig. 2.

Nodosaria inconstans Id. Ibid. 38. pl. i. figs. 6, 7.

Glandulina tenuis Bornemann. 1854. Lias-formation. 31. pl. ii. fig. 3. a, b.

Glandulina major Id. Ibid. 31. pl. ii. fig. 4. a, b.

Nodosaria geinitzi Reuss. 1854. Jahresb. d. Wetterauer Gesellsch. 1851–53. 77. fig. 12.

Glandulina elegans Neugeboren. 1856. Denkschr. d. K. Akad. Wiss. Wien. 69. pl. i. fig. 5.

Glandulina reussi Id. Ibid. 69. pl. i. fig. 6.

Nodosaria beyrichi Id. Ibid. 72. pl. i. figs. 7–9.

Nodosaria incerta Id. Ibid. 72. pl. i. figs. 10, 11.

Nodosaria radicula Jones and Parker. 1860. Quart. Journ. Geol. Soc. xvi. 453. figs. 1–5 (Triassic).

Nodosaria geinitzi Richter. 1855. Zeitschr. d. deutsch. Geol. Gesellsch. vii. 532. pl. xxvi. fig. 26.

Nodosaria kirbyi Richter. 1861. Geinitz's Dyas. 121. pl. xx. fig. 30.

Glandulina conica Terquem. 1862. Foram. du Lias. 2ième mém. 435. pl. v. fig. 10. a, b.

Nodosaria jonesi Reuss. 1862. Sitzungsb. d K. Akad. Wiss. Wien. xlvi. 89. pl. xii. fig. 6.

Nodosaria claviformis Terquem. 1866. Foram. du Lias. 6ième mém. 447. pl. xix. figs. 17, 18.

Nodosaria radicula Brady. 1867. Proc. Somerset Arch. and Nat. Hist. Soc. xiii. 106. pl. i. fig. 4.

Nodosaria conferta Schmid. 1867. Neues Jahrb. für Min. Jahrg. 1857. 585. pl. vi. fig. 49.

Nodosaria radicula Brady. 1876. Pal. Soc. xxx. 124. pl. x. figs. 6–16.

Nodosaria radicula Brady. 1884. Report on Foram. H. M. S. Challenger. Zool. ix. 495. pl. lxi. figs. 28–31.

Test cylindrical, tapering, composed of several subglobose segments united in a straight line. Surface smooth more or less. A good typical specimen of *Nodosaria radicula* has four or more segments, rarely as many as eight; the segments are subglobular in form, regularly but only slightly increasing in size, from the earliest to the last formed, and quite symmetrically joined end to end.

Locality. Timber Creek, in the yellow limestone. Rare.

NODOSARIA RAPHANUS Linné, sp.

"*Cornu Hammonis erectum striatum*" Plancus. 1739. Conch. Min. 15. pl. i. fig. 6.

"*Orthoceras minimum*," etc. Gaultieri. 1742. Index Test. pl. xix. fig. L.

Nautilus raphanus Linné. 1767. Syst. Nat. 12th ed. 1164, 283; 1788. Ibid. 13th (Gmelin's) ed. 3372. No. 16.

"*Orthoceratia seu tubuli*" Soldani. 1791. Testaceographia. i. pt. 2. 91. pl. xciv. figs. T, V.

Nautilus costatus Montagu. 1803. Test. Brit. 199. pl. xiv. fig. 5.

Nautilus costatus, var. Montagu. 1808. Test. Brit. Suppl. 83. pl. xix. fig. 2.

Orthocera raphanus Lamarck. 1822. Anim. sans Vert. vii. 593. No. 1; Tabl. Encycl. et Méth. pl. cccclxv. fig. 2. a, b, c.

Nodosaria scalaris d'Orbigny. 1826. Ann. Sci. Nat. vii. 253. No. 18.

Nodosaria rapa Id. Ibid. 253 No. 27.

Nodosaria obscura Reuss. 1845. Verstein. böhm. Kreid. pt 1. 26. pl. xiii. figs. 7–9.

Nodosaria bolli Reuss. 1855. Zeitschr. d. deutsch. geol. Gesellsch. vii. 265. pl. viii. fig. 6.

Nodosaria propinqua Costa. 1856. Atti dell' Accad. Pont. vii. 151. pl. xiii. fig. 2.

Nodosaria turgidula Costa. 1856. Atti dell' Accad. Pont. vii. 152. pl. xiii. fig. 3.

Nodosaria raphanus Parker and Jones. 1859. Ann. and Mag. Nat. Hist. ser. 3. iii. 477.

Dentalina pulchra Gabb. 1860. Jour Acad. Sci. Phila. n. s. iv. 402. pl. lxix figs. 40, 41.

Nodosaria bactroides Reuss. 1862. Sitzungsb. d. K. Akad. Wiss. Wien. xlvi. 37. pl. ii. fig. 5.

Nodosaria lamelloso-costata Id. Ibid. 38. pl. ii fig. 6.

Nodosaria prismatica Id. Ibid. 36. pl. ii. fig. 7.

Nodosaria raphanus Silvestri. 1872. Nodos. Foss. e Viv. d'Ital. 43. pl. iv. figs. 67–81.

Phonemus (*Dentalina*) *pulcher* Meek. 1864. Smithsonian Inst. Mis. Coll. 177. p. 1. 1868. Appendix A. Geology of New Jersey. 721.

Nodosaria raphanus Jones, Parker, and Brady. 1866. Monograph. Foram. of the Crag 49. pl. i. figs. 4, 5, 22, 23.

Nodosaria obscura Reuss. 1874. Das Elbthalgebirge in Sachsen. pt. ii. 81. pl. xx. fig. 14.

Nodosaria raphanus Brady. 1884. Report on Foram. H. M. S. Challenger. Zool. ix. 512. pl. lxiv. figs 6–10.

Shell straight, subcylindrical, tapering, composed of a few largish chambers, and externally ribbed from end to end by stout parallel ridges. The constrictions marking the septal lines are sometimes concealed by overgrowing longitudinal costæ. Liable to become either curved or compressed, or both, with more or less eccentric aperture.

Locality. Timber Creek, in the teredo bed. Rare.

NODOSARIA RAPHANISTRUM Linné, sp.

Nautilus raphanistrum Linn. 1758. Syst. Nat. 10th ed. 710. No. 242; 1767. 12th ed. 1163. No. 282.

Orthocera raphanistrum Lamarck. 1822. An. s. Vert. 594. No. 3.

Nodosaria bacillum Defrance. 1825. Dict. Sci. Nat. xxxv. 127; xxvi. 487; Atlas Conch. 13. fig. 4.

Nodosaria zippei Reuss. 1844. Kreidegebirg. 210; 1845. Verst. böhm. Kreid. i. 25. pl. viii. figs. 1–3.

Nodosaria bacillum d'Orbigny. 1846. For. Foss. Vien. 40. pl. i. figs. 40–47.

Nodosaria raphanus Parker and Jones. 1860. Quart. Journ. Geol. Soc. xvi. 453. pl. xix. fig. 10.

Nodasaria spectrum Reuss. 1862. Sitzungsb. Akad. Wien. Math. Nat. Cl. xlvi. 37. pl. ii. fig. 3.

Nodosaria biformis, *N. bactridium* Reuss. 1866. Denks. Akad. Wien. xxv. 14. pl. i. figs. 23–25.

Nodosaria raphanistrum Jones, Parker, and Brady. 1866. Foram. of the Crag. 50. pl. i. figs. 6–8.

Nodosaria raphanistrum Sherborn and Chapman. 1886. Journ. Roy. Mic. Soc. ser. 2. vi. 749. pl. xiv. fig. 37.

Test long, straight, cylindrical, many chambered; septa more or less constricted; surface ornamented by numerous stout parallel ribs running from end to end of the shell.

Locality. Stratton's marl pit, near Mullica Hill, in the shell layers of the green marl. Common. Also at Timber Creek, yellow limestone. Rare. Gryphæa bed. Rare.

NODOSARIA SCALARIS Batsch, sp.

"*Orthocerata striata microscopica*" Soldani. 1780. Saggio Oritt. 107. pl. v. figs. L, A, B, C, D; pl. viii. fig. CC.

"*Orthoceratia flosculi*" Soldani. 1791. Testaceographia. i. pt. 2. 91. pl. xcv. figs. B–M.

"*Polymorphia pineiformia*" Soldani. 1791. Ibid. 118. pl. cxxvii. fig. C.

Nautilus (*Orthoceras*) *scalaris* Batsch. 1791. Conchyl. des Seesandes. No. 4. pl. ii. fig. 4. a, b.

Nodosaria longicauda d'Orbigny. 1826. Ann. Sci. Nat. vii. 254. No. 28.

Nodosaria sulcata Id. Ibid. 253. No. 21.

Nodosaria candei d'Orbigny. 1839. Foram. Cuba. 44 pl. i. figs. 6, 7.

Nodosaria striaticollis d'Orbigny. 1839. Foram. Canaries. 124. pl. i. figs. 2–4.

Lagena williamsoni (?) Harvey and Bailey. 1853. Proc. Acad. Phila. vi. 431.

Nodosaria tenuicostata Costa. 1856. Atti dell' Accad. Pont. vii. 156. pl. xii. fig. 5; pl. xvi. figs. 8–13.

Nodosaria reussi Id. Ibid. 155. pl. xvi. fig. 5.

Nodosaria annulata Costa. 1857. Mém. Accad. Sci. Nap. ii. 139. pl. i. fig. 16.

Nodosaria radicula Williamson. 1858. Rec. Foram. Gt. Br. 15. pl. ii. figs. 36–38.

Nodosaria scalaris Parker and Jones. 1865. Phil. Trans. clv. 340. pl. xvi. fig. 2. a, b, c.

Nodosaria subradicula Schwager. 1866. Novara Exped. geol. ii. 222. pl. v. fig. 50.

Nodosaria longicauda Silvestri. 1872. Nodos. Foss. e Viv. d'Ital. 58. pl. v. figs. 101–127.

Nodosaria scalaris Brady. 1884. Report on Foram. H M. S. Challenger. Zool. ix. 510. pl. lxiii. figs. 28–31; var. pl. lxiv. figs. 16–19.

"Test is straight; the segments comparatively few, generally from three to six in the adult shell and never more than eight, inflated or subglobular, and increasing rapidly, though not always regularly, in size. The final chamber is drawn out into an apertural tube of some length with a terminal phialine lip, and the opposite extremity of the test is commonly mucronate. The superficial costæ vary both as to number and thickness, and are frequently more numerous and less strongly marked than shown by the figures.'—Brady, loc. cit.

Locality. Stratton's marl pit, near Mullica Hill, in the shell layers of the green marl. Frequent. Timber Creek, in the yellow limestone. Quite rare.

NODOSARIA (D.) SOLUTA Reuss.

Dentalina oligostegia Reuss. 1850. Haidinger's Naturw. Abhandl. iv. 25. pl. ii. fig. 10.

Dentalina lilli Id. Ibid. 25. pl. ii. fig. 11.

Dentalina soluta Reuss. 1851. Zeitschr. d. deutsch. geol. Gesellsch. iii. 60. pl. iii. fig. 4. a, b.

Dentalina globifera Reuss. 1855. Sitzungsb. d. K. Ak. Wiss. Wien. xviii. 223. pl. i. fig. 3.

Nodosaria soluta Bornemann. 1855. Zeitschr. d. deutsch. geol. Gesellsch. vii. 322. pl. xii. fig. 12.

Dentalina globuligera Neugeboren. 1856. Denkschr. d. K. Akad. Wiss. Wien. xii. 81. pl. ii. fig. 10.

Nodosaria ovularis Costa. 1857. Mem. Accad. Sci. Napoli. ii. 141. pl. i. figs. 8, 9.

Dentalina distincta Reuss. 1860. Sitzungsb. d. K. Akad. Wiss. Wien. xl. 184. pl. ii. fig. 5.

Dentalina catenula Id. Ibid. 185. pl. iii. fig. 6.

Dentalina discrepans Id. Ibid. 184. pl. iii. fig. 7

Dentalina soluta Stache. 1864. Novara Exped. geol. i. Paläont. 203. pl. xii. fig. 29.

Nodosaria (*D.*) *grandis* Reuss. 1865. Denkschr d. K. Akad. Wiss. Wien. xxv. 131. pl. i. figs. 26–28.

Nodosaria (*D.*) *soluta* Id. Ibid. 131. pl. ii. figs. 4–8.

Nodosaria (*D.*) *guttifera* Parker and Jones. 1865. Phil. Trans. clv. 343. pl. xiii. fig. 11.

Dentalina soluta Hantken. 1875. Mitth. Jahrb. d. K. ung. geol. Anstalt. iv. 29. pl. ii. figs. 2, 14.

Nodosaria (*D.*) *soluta* Brady. 1884. Report on Foram. H. M. S. Challenger. Zool. ix. 503. pl. lxii. figs. 13–16; pl. lxiv. fig. 28.

Test elongate, a little arcuate, with a few spherical chambers; with constricted interstices, first chamber somewhat mucronate, the last produced into a short siphon; aperture naked.

Locality. Timber Creek, in the yellow limestone. Rare. Teredo bed. Frequent.

NODOSARIA VERTEBRALIS Batsch, sp.

Nautilus (*Orthoceras*) *vertebralis* Batsch. 1791. Conchyl. des Seesandes. 3. No. 6. pl. ii. fig. 6. a, b.

Nodosaria fascia Parker, Jones, and Brady. 1865. Ann. and Mag. Nat. Hist. ser. 3. xv. 227. No. vi.

Nodosaria vertebralis Brady. 1884. Report on Foram. H. M. S. Challenger. Zool. ix. 514. pl. lxiii. fig. 35 ; pl. lxiv. figs. 11–14.

"The shell of *Nodosaria vertebralis* is long, slender, slightly tapering, and generally more or less curved ; the segments are very numerous and the septal lines straight; and the surface is marked by distinct, continuous, longitudinal striæ or riblets. The outline is even and the sutures are unconstricted ; the septa are conspicuously thick and formed of transparent shell substance, but not limbate externally."—Brady, loc. cit.

Locality. Stratton's marl pit, near Mullica Hill, in the shell layers of the green marl. Rare. Timber Creek, teredo bed. Not abundant.

LINGULINA d'Orbigny.

LINGULINA CARINATA d'Orbigny.

Lingulina carinata d'Orbigny. 1826. Ann. Sci. Nat. vii. 257. No. 1 ; Modèle. No. 26.

Lingulina carinata d'Orbigny. 1839. Foram. Canaries. 124. pl. i. figs. 5, 6.

Lingulina carinata Williamson. 1858. Rec. Foram. Gt. Br. 14. pl. ii. figs. 33–35.

Lingulina carinata Parker and Jones. 1860. Foram. Chellast. Quart. Journ. Geol. Soc. xvi. pl. xix figs. 13, 14.

Frondicularia nysti Reuss. 1863. Crag. d'Anvers Bull. Acad. Belg. ser. 2. xv. 148. pl. ii. fig. 20.

Lingulina bursæformis Gümbel. 1868. Nordalp. Eocän. K. Bayr. Akad. Abhandl. I. x. 628. pl. i. fig. 51.

Lingulina pygmæa Reuss. 1873. Geinitz' Elbthalgeb. Sachsen. 2. 90. II. 20. fig. 23.

Lingulina glabra Hantken. 1875. Mitth. Jahrbuch. d. K. ungar. geol. Anstalt. iv. 42. pl. xiii. fig. 14.

Nodosarina carinata Goës. 1882. Kongl. Svenska Vet. Akad. xix. pl. i. figs. 65–67.

Lingulina carinata Brady. 1884. Report on Foram. H. M. S. Challenger. Zool. ix. 517. pl. lxv. figs. 16, 17.

Test oblong-elongate, compressed, carinate, shining, smooth, translucent, anteriorly rotund, posteriorly cuneate, with numerous inequal chambers; aperture linear, transverse.

Locality. Timber Creek, teredo bed. Rare. Gryphæa bed. Rare.

FRONDICULARIA Defrance.

FRONDICULARIA ALATA d'Orbigny.

"*Nautili caudiformes*" Soldani. 1798. Testaceographia. ii. 13. pl. i. fig. C.

Frondicularia alata d'Orbigny. 1826. Ann. Sci. Nat. vii. 256. No. 2.

Frondicularia alata Parker, Jones, and Brady. 1871. Ann. and Mag. Nat. Hist. ser. 4. viii. 161. pl. x. fig. 66.

Frondicularia alata, var. *sagittula* Vanden Broeck. 1876. Ann. Soc. Belg. Micr. ii. 113. pl. ii. figs. 12, 14.

Frondicularia alata, var. *lanceolata* Id. Ibid. 117. pl. ii. fig. 13.

Frondicularia complanata, var. *concinna* Id. Ibid. 109. pl. iii. fig. 2.

Frondicularia alata Brady. 1884. Report on Foram. H. M. S. Challenger. Zool. ix. 522. pl. lxv. figs. 20–23; var. pl. lxvi. figs. 3–5.

"The figure in the Testaceographia, selected by d'Orbigny to bear the name *Frondicularia alata*, is that of a short complanate shell, which is very broad near the initial end, owing to the arms of the V-shaped segments reaching back nearly into a line with the primordial chamber. The free ends of the segments are irregular, and most of them projecting and pointed. The drawing is somewhat rough, but represents in their extreme development characters easily recognized in more typical specimens.

"Referring to the illustrations, the two large figures (figs. 20, 21) represent good examples of the species in the adult condition, the free ends of the chambers forming a nearly straight line, and one here and there extended into a projecting point. Such shells attain large dimensions, the length sometimes exceeding one-fifth inch (5 mm.). Vanden Broeck (*loc. cit.*) gives an excellent series of drawings, representing individual modifications of the species rather than distinct varieties."—Brady, loc. cit.

Locality. Stratton's marl pit, near Mullica Hill. Frequent. Timber Creek, teredo bed. Rare. Gryphæa bed. Rare. Yellow limestone. Rare.

FRONDICULARIA ANGUSTA Nilsson, sp.

Planularia angusta Nilsson. 1827. Petrifacta Suecana. 11. pl. ix. fig. 22.

Frondicularia angustata Roemer. 1827. Petrifacta Suecana. 96.

Frondicularia angusta Reuss. 1844. Geog. Skizzen. aus Böh. ii. 211.

Frondicularia angusta Geinitz. 1844. Geog. Skizzen. aus Böh. ii. 70. pl. xvii. fig. 22.

Frondicularia angusta Reuss. 1845. Versteinerungen der böh. Kreid. 20. pl. viii. figs. 13, 14.

"Test 2–6‴ elongate, small, lancet-shaped, at the lower end much elongated, above pointed, broadest at or above the centre. From the centre out to the marginal borders decreasing. Numerous (15–25) very small chambers, which are separated by proportionally broad roof-shaped sloping edges. These are interrupted in the centre by a longitudinal furrow which is smaller below, and moreover striated by more fine short lateral furrows, which nevertheless are not continued into the spaces between the edges. The lowest chamber very small, quite spherical, on every side provided with thin sharp longitudinal ribs and a short point on the base. The tolerably sharp lateral margin is continued over the first chamber to the end of the shell."—Reuss, loc. cit.

Locality. Stratton's marl pit, near Mullica Hill, in the shell layers of the green marl. Quite rare. Bruere's pits, Crosswick's Creek, lower marl bed, above the gray layer. Rare. Timber Creek, in the teredo bed. Quite rare.

MARGINULINA d'Orbigny.

MARGINULINA COSTATA Batsch, sp.

Nautilus (*Orthoceras*) *costatus* Batsch. 1791. Conchyl. des Seesandes. 2. pl. i. fig. 1. a–g.

"*Orthoceratia, Raphanus, Raphanistrum* et *Rapistrum*" Soldani.

1791. Testaceographia. i. pt. 2. 91. pl. xciv. figs. N, P, Q, R, X, Y.

Marginulina raphanus d'Orbigny. 1826. Ann. Sci. Nat. vii. 258. No. 1. pl. x. figs. 7, 8; Modèle. No. 6.

Marginulina interamniæ Costa. 1856. Atti dell' Accad. Pont. vii. 184. pl. xiii. fig. 9.

Marginulina obliquestriata Karrer. 1861. Sitzungsb. d. K. Akad. Wiss. Wien. xliv. 446. pl. i. fig. 8.

Marginulina striatocostata Reuss. 1862. Ibid. xlvi. 62. pl. vi. fig. 2.

Marginulina turgida Id. Ibid. 63. pl. vi. fig. 7.

Marginulina raphanus Parker, Jones, and Brady. 1865. Ann. Mag. Nat. Hist. ser. 3. xvi. 19. pl. i. fig. 35.

Marginulina hamus Terquem. 1866. Foram. du Lias. 6ième mém. 501. pl. xxi. fig. 8. a, b.

Marginulina radiata Id. Ibid. 505. pl. xxi. figs. 16, 17.

Marginulina, var. *crebicosta* Seguenza. 1880. Atti R. Accad. dei Lincei. ser. 3. vi. 90. pl. ix. fig. 6.

Marginulina costata Brady. 1884. Report on Foram. H. M. S. Challenger. Zool. ix. 528. pl. lxv. figs. 10–13.

Test elongate, cylindrical, the chambers or members separated from each other like balls, but are connected by strong ribs, which unbrokenly extend over the entire shell and for the most part have a rectilinear back.

Locality. Timber Creek, teredo bed. Rare.

VAGINULINA d'Orbigny.

VAGINULINA LEGUMEN Linné, sp.

Nautilus legumen Linné. 1758. Syst. Nat. 10th ed. 711. No. 248; 1767. 12th ed. 1164. No. 288.

Nautilus (*Orthoceras*) *leguminiformis* Batsch. 1791. Conchyl. des Seesandes. No. 8. pl. iii. fig. 8. a.

Vaginulina legumen d'Orbigny. 1826. Ann. Sci. Nat. vii. 257. No. 2.

Vaginulina lævigata Roemer. 1838. Neues. Jahrb. für Min. etc. 383. pl. iii. fig. 11.

Vaginulina elongata Roemer. 1840. Verst. Nordd. Kreid. 96. pl. xv. fig. 13.

Nodosaria legumen Reuss. 1845. Verst. böhm. Kreid. part 1. 28. pl. xiii. figs. 23, 24.

Dentalina legumen Williamson. 1858. Rect. Foram. Gt. Br. 21. pl. ii. fig. 45.

Vaginulina legumen Jones, Parker, and Brady. 1866. Monogr. Foram. Crag. 64. pl. iv. fig. 9.

Vaginulina legumen Brady. 1884. Report on Foram. H. M. S. Challenger. Zool. ix. 530. pl. lxvi. figs. 13–15.

Test smooth, sometimes straight, often arcuate, and sometimes considerably so; slightly compressed laterally; consisting of a linear series of flat, smooth, oblique segments, rarely exceeding twelve in number. Primordial segment abruptly truncate; sometimes cuneiform; occasionally prolonged into a large, solid, transparent mucro. Peripheral outline entire, and not lobulated; though sometimes having the ultimate segment ventricose, and separated from the rest by a deeply constricted septal line. Septal lines smooth, oblique; tending backwards as they approach the convex margin of the shell. Septal aperture at the extremity of the ultimate segment, which extremity is not central, but at the concave margin; surrounded by a well-defined coronal.

Locality. Stratton's marl pit, near Mullica Hill, in the shell layers of the green marl. Rare.

VAGINULINA LINEARIS Montagu, sp.

Nautilus linearis Montagu. 1808. Test. Brit. Suppl. 87. pl. xxx. fig. 9.

Marginulina vaginella Reuss. 1851. Zeitschr. d. deutsch. geol. Gesellsch. iii. 152. pl. viii. fig. 2.

Vaginulina striata Costa. 1856. Atti dell' Accad. Pont. vii. 182. pl. xvi. fig. 17.

Dentalina legumen, var. *linearis* Williamson. 1858. Rect. Foram. Gt. Br. 23. pl. ii. figs. 46–48.

Vaginulina linearis Parker and Jones. 1865. Phil. Trans. clv. 343. xiii. figs. 12, 13.

Vaginulina linearis Jones, Parker, and Brady. 1866. Monograph of the Foram. of the Crag. 67. pl. i. figs. 10–12.

Vaginulina eocæna Gümbel. 1868. Abhand. d. K. bayer. Akad. d. Wiss. II. Cl. x, 632. pl. i. fig. 48. a, b.

Cristellaria dilute-striata Id. Ibid. 639. pl. i. fig. 69.
Vaginulina linearis Brady. 1884. Report on Foram. H. M. S. Challenger. Zool. ix. 532. pl. lxvii. figs. 10–12.

Test straight or bent, more or less compressed ; chambers compactly set on, more or less oval in section ; ornamented in a variable degree with delicate parallel riblets, mostly oblique to axis of the shell ; aperture eccentric.

Locality. Stratton's marl pit, near Mullica Hill, in the shell layers of the green marl. Rare. New Egypt, in the lower green marl. Fragments. Bruere's pits, Crosswick's Creek, lower marl bed, above the gray layers. Rare.

CRISTELLARIA Lamarck.

CRISTELLARIA ACUTAURICULARIS Fichtel and Moll, sp.

"*Hammoniæ subrotundæ*," etc. Soldani. 1789. Testaceographia. i. pt. 1. 61. pl. xlix. fig. x.
Nautilus acutauricularis Fichtel and Moll. 1803. Test. Micr. 102. pl. xviii. figs. g–i.
Cristellaria navicula d'Orbigny. 1840. Mém. Soc. géol. France. iv. 27. pl. ii. figs. 19, 20.
Cristellaria polita Reuss. 1855. Sitzungsb. d. K. Akad. Wiss. Wien. xviii. 237. pl. iii. fig. 41.
Robulina limbata (pars) Bornemann. 1855. Zeitschr. d. deutsch. geol. Gesellsch. vii. 335. pl. xv. figs. 4, 5.
Cristellaria acutauricularis Parker and Jones. 1860. Ann. and Mag. Nat. Hist. ser. 3. v. 114. No. 20.
Cristellaria acutauricularis Brady. 1884. Report on Foram. H. M. S. Challenger. Zool. ix. 543. pl cxiv. fig. 17. a, b.

Test spiral, involute, suboval, smooth, ventricose, exumbilicate, keel acute carinate ; convolutions with ten conspicuous subelevated joints ; dissepiments moderately convex in front, oval plane ovate-convex, marginate, with the exterior angle compressed, obtuse, subincurvate ; with orifice in the extremity of the said angle minutely rotund.

Locality. Timber Creek, in the gryphæa bed. Rare.

CRISTELLARIA ARTICULATA Reuss.

Robulina articulata Reuss. 1863. Sitzungsb. d. K. Akad. Wiss. Wien. xlviii. 53. pl. v. fig. 62.

Cristellaria articulata Id. 1870. Ibid. lxii. 483 ; Schlicht. 1870. Foram. Pietzpuhl. pl. xvii. figs. 5–12.

Cristellaria articulata Brady. 1884. Report on Foram. H. M. S. Challenger. Zool. ix. 547. lxix. figs. 10–12 ; wild-growing forms. figs. 1–4.

Test quite circular, slightly angular, compressed, in the centre slightly beaked, with six to eight curved chambers of which the last are moderately broadly triangular, considerably arched, separated by deep sutures, the septal walls of the last chamber oval, deeply outlined on the base, slightly convex.

Locality. Stratton's marl pit, near Mullica Hill, in the shell layers of the green marl. Quite rare. Timber Creek, teredo bed. Rare.

CRISTELLARIA CREPIDULA Fichtel and Moll, sp.

Nautilus crepidula Fichtel and Moll. 1803. Test. Micr. 107. pl. xix. figs. g–i.

Cristellaria crepidula d'Orbigny. 1839. Foram. Cuba. 64. pl. viii. figs. 17, 18.

Cristellaria berthelotiana d'Orbigny. 1839. Foram. Canaries. 125. pl. i. figs. 14, 15.

Cristellaria intermedia Reuss. 1845. Verstein. böhm. Kreid. pt. i. 33, 108. pl. xiii. figs. 57, 58 ; pt. ii. pl. xxiv. figs. 50, 51.

Cristellaria cymboides d'Orbigny. 1846. Foram. Foss. Vien. 85. pl. iii. figs. 30, 31.

Cristellaria intermedia Alth. 1850. Haidinger's Naturw. Abhandl. iii. 267. pl. xiii. fig. 23.

Cristellaria jugleri Reuss. 1851. Zeitschr. d. deutsch. geol. Gesellsch. iii. 89. pl. iv. fig. 19. a, b.

Cristellaria subarcuatula Williamson. 1858. Rect. Foram. Gt. Br. 29. pl. ii. figs. 56, 57.

Cristellaria intermedia Reuss, var. 1861. Sitzungsb. d. K. Akad. Wiss. Wien. xliv. 328. pl. viii. fig. 2.

Cristellaria grata Reuss. 1862. Sitzungsb. d. K. Akad. Wiss. Wien. xlvi. 70. pl. vii. fig. 14.

Cristellaria planiuscula Id. Ibid. 71. pl. vii. fig. 15.

Cristellaria cordiformis Terquem. 1863. Foram. du Lias. 3$^{\text{ième}}$ mém. 203. pl. ix. fig. 14. a, b.

Cristellaria acuminata Id. Ibid. 210. pl. x. fig. 5. a, b.

Hemirobulina compressa Stache. 1864. Novara Exped. i. Paläont. 229. pl. xxiii. fig. 8. a, b.

Cristellaria crepidula Parker and Jones. 1865. Phil. Trans. clv. 344. pl. xiii. figs. 15, 16; pl. xvi. fig. 4.

Cristellaria kochi Reuss. 1866. Denkschr. d. K. Akad. Wiss. Wien. xxv. 139. pl. ii. fig. 35. a, b.

Cristellaria galeata Id. Ibid. 141. pl. iii. fig. 8. a, b.

Cristellaria crepidula Brady. 1884. Report on Foram. H. M. S. Challenger. Zool. ix. 542. pl. lxvii. figs. 17, 19, 20; pl. lxviii. figs. 1, 2.

Test spiral subinvolute, elongate, slightly curved, smooth, pellucid, compressed, with subelevated sides, back obtuse, 12–13 conspicuous chambers, planate except the last which is more elevated; chamber walls slightly convex anteriorly, radiating from a common centre with the last two or three, scarcely elevate plane-oval lanceolate convex; orifice minute rotund slightly crenate on the outside of the angle.

Locality. Stratton's marl pit, near Mullica Hill, in the shell layers of the green marl. Rare.

CRISTELLARIA CULTRATA Montfort, sp.

"*Cornu Hammonis*" Plancus. 1760. Conch. Min. ed. altera. 120. pl. i. fig. xii. sec. 552.

"*Nautili* (*Lenticulæ marginatæ*)" Soldani. 1789. Testaceographia. i. pt. 1. 54. pl. xxxiii. figs. B etc.

Robulus cultratus Montfort. 1808. Conchyl. Systèm. i. 214 54^{e} genre.

Robulina cultrata d'Orbigny. 1826. Ann. Sci. Nat. vii. 287. No. 1; Modèle No. 82.

Robulina canariensis d'Orbigny. 1839. Foram. Canaries. 127. pl. iii. figs. 3, 4.

Robulina subcultrata d'Orbigny. 1839. Foram. Amér. Mérid. 26. pl. v. figs. 19, 20.

Robulina cultrata d'Orbigny. 1846. Foram. Foss. Vien. 96. pl. iv. figs. 10–13.

Robulina similis d'Orbigny. Ibid. 98. pl. iv. figs. 14, 15.
Cristellaria hoffmanni Ehrenberg. 1854. Mikrogeologie. pl. xxvi. fig. 53.
Robulina limbosa Reuss. 1863. Sitzungsb. d. K. Akad. Wiss. Wien. xlviii. 55. pl. vi. fig. 69.
Cristellaria gyroscalprum Stache. 1864. Novara Exped. geol. i. Paläont. 243. pl. xxiii. fig. 22. a, b.
Robulina cultrata, var. *antipodum* Id. Ibid. 251. pl. xxiii. fig. 30. a, b.
Robulina tættovata Id. Ibid. 253. pl. xxiii. fig. 32. a, b.
Cristellaria cultrata Parker and Jones. 1865. Phil. Trans. clv. 344. pl. xiii. figs. 17, 18; pl. xvi. fig. 5.
Robulina curvispira Seguenza. 1879. Atti R. Accad. dei Lincei. ser. 3. vi. 144. pl. xiii. fig. 28.
Robulina stellata Id. Ibid. 144. pl. xiii. fig. 29.
Robulina dubia Id. Ibid. 144. pl. xiii. fig. 30.
Cristellaria cultrata Brady. 1884. Report on Foram. H. M. S. Challenger. Zool. ix. 550. pl. lxx. figs. 4, 5, 6, 7, 8.
Cristellaria cultrata Whiteaves. 1887. Trans. Roy. Soc. Can. iv. 114.

Test orbicular-convex, smooth, or radiate, costate, carinate margin, lamellose; with eight oblique chambers, somewhat convex, smooth or costate, with the last excavated above, aperture radiate.

Locality. Stratton's marl pit, near Mullica Hill, in the shell layers of the green marl. Common. Bruere's pit, Crosswick's Creek, lower marl bed above the gray layers. Not common. New Egypt, green marl. Fragments. Timber Creek, teredo bed. Common. Marlborough, green marl. Quite abundant.

CRISTELLARIA GIBBA d'Orbigny.

Cristellaria gibbia d'Orbigny. 1839. Foram. Cuba. 63. pl. vii. figs. 20, 21.
Cristellaria excisa Bornemann. 1855. Zeitschr. d. deutsch. geol. Gesellsch. vii. 328. pl. xiii. figs. 19, 20.
Cristellaria nuda Reuss. 1861. Sitzungsb. d. K. Ak. Wiss. Wien. xliv. 328. pl. vi. figs. 1–3.
Cristellaria pulchella Id. 1862. Ibid. xlvi. 71. pl. viii. fig. 1.

Robulina concinna Id. 1863. Ibid. xlviii. 52. pl. v. fig. 58.

Cristellaria gibba Brady. 1884. Report on Foram. H. M. S. Challenger. Zool. ix. 546. pl. lxix. figs. 8, 9.

Test oblong-convex, inflated, subcarinate, smooth, shining, yellowish ; ten elongate chambers, arcuate, terminal one subconcave above, margined, with sutures complanate, umbilicus impressed ; aperture marginate, radiate.

Locality. Stratton's marl pit, near Mullica Hill, in the shell layers of the green marl. Quite rare. Timber Creek, teredo bed. Quite rare. Gryphæa bed. Rare.

CRISTELLARIA ITALICA Defrance, sp.

Saracenaria italica Defrance. 1824. Dict. Sci. Nat. xxxii. 177 ; xlvii. 344. Atlas Conch. pl. xiii. fig. 6.

Saracenaria italica Blainville. 1825. Man. de Malacol. 370. pl. v. fig. 6.

Cristellaria (*Saracenaria*) *italica* d'Orbigny. 1826. Ann. Sci. Nat. vii. 293. No. 26. Modèles Nos. 19 and 85.

Frondicularia triedra Costa. 1856. Atti dell' Accad. Pont. vii. 174. pl. xiii. figs. 26, 27.

Cristellaria italica Parker, Jones, and Brady. 1865. Ann. and Mag. Nat. Hist. ser. 3. xvi. 22, 32. pl. i. figs. 41, 42.

Cristellaria (*Marginulina*) *italica*, var. *cincta* Karrer. 1877. Geol. K. F.-J. Wasserleitung. 383. pl. xvi. b. fig. 38.

Cristellaria (*Marginulina*) *italica,* var. *aureola* Id. Ibid. 383. pl. xvi. b. fig. 39.

Cristellaria italica Brady. 1884. Report on Foram. H. M. S. Challenger. Zool. ix. 544. pl. lxviii. figs. 17, 18, 20–23.

"*Saracenaria.* Shell almost microscopical, oval, celled, with a sort of sinuous keel in its middle, from which start oblique striæ, indications of interior partitions, not sinuous, which divide its cavity into two ranges of chambers ; no trace of an exterior opening."—D'Blainville. 370. pl. v. fig. 6.

"The test of *Cristellaria italica* is elongate and trihedral ; the planospiral segments are few and inconspicuous, whilst those of the body of the shell are superimposed so as to form a curved line. The convex or dorsal margin is sharp but not carinate, and the ventral face is so broad that the transverse section of the shell has the form of a nearly equilateral triangle. The segments are short and obliquely set, dipping at the front more or less towards the initial end, as in *Vaginulina*."—Brady, loc. cit.

Locality. Stratton's marl pit, near Mullica Hill, in the shell layers of the green marl. Rare.

This being such a peculiar species I have given the original generic description and specific characters given by my esteemed friend, H. B. Brady.

CRISTELLARIA ROTULATA Lamarck, sp.

'*Cornu Hammonis* seu *Nautili*" Plancus. 1739. Conch. Minn. 13. pl. i. fig. III.

Lenticulites rotulata Lamarck. 1804. Ann. du Muséum. v. 188. No. 3; Tableau Encycl. et Méth. pl. cccclxvi fig. 5.

Robulina muensteri Roemer. 1841. Verstein. norddeutsch. Kreid. pt. 2. 98. pl. xv. fig. 30.

Cristellaria rotulata Forbes. 1845. Quart. Journ. Geol. Soc. i. 65, 66. fig.

Robulina simplex d'Orbigny. 1846. Foram. Foss. Vien. 102. pl. iv. figs. 27, 28.

Robulina stellifera Czjzek. 1847. Haidinger's Naturw. Abhandl. ii. 142. pl. xii. figs. 26, 27.

Robulina trigonostoma Reuss. 1851. Zeitschr. d. deutsch. geol. Gesellsch. iii. 69. pl. iv. fig. 26.

Robulina neglecta Id. Ibid. 69. pl. iv. fig. 27.

Robulina deformis (pars) Bornemann. 1855. Ibid. vii. 337. pl. xiv. fig. 1.

Robulina depauperata Id. Ibid. 337. pl. xiv. fig. 11.

Robulina incompta (?) Id. Ibid. 336. pl. xiv. fig. 12.

Cristellaria calcar (typica) Williamson. 1858. Rec. Foram. Gt. Br. 27. pl. ii. figs. 52, 53.

Cristellaria rotulata Reuss. 1861. Sitzungsb. d. K. Akad. Wiss. Wien. xliv. 326, 336.

Phonemus (*Cristellaria*) *rotulatus* (d'Orbigny ?) Meek. 1864. Smithsonian Inst. Mis. Coll. 177. i.

Cristellaria rotulata Parker and Jones. 1865. Phil. Trans. clv. 345. pl. xiii. fig. 19.

Cristellaria inornata Terquem. 1876. Anim. sur la Plage de Dunkerque. 70. pl. vii. fig. 18.

Cristellaria austriaca Id. Ibid. 70. pl. vii. fig. 20. a, b.

Cristellaria simplex Id. Ibid. 70. pl. vii. fig. 21. a, b.

Robulina simplicissima Seguenza. 1879. Atti R. Accad. dei Lincei. ser. 3. vi. 141. pl. xiii. fig. 18.

Robulina lucida Id. Ibid. 142. pl. xiii. fig. 19.

Cristellaria falcifer Stache. 1864. Novara Exped. geol. i. Paläont. 240. pl. xxiii. fig. 19 a, b.

Cristellaria rotulata Schlumberger. 1882. Journ. Cin. Soc. Nat. Hist. v. 119 pl. v. figs. 2, 2a.

Cristellaria rotulata Brady. 1884. Report on Foram. H. M. S. Challenger. Zool. ix. 547. lxix. fig. 13. a, b.

Test orbiculate, convex, smooth, non-costate sutures forming a star in the plane centre, without central disc, margin narrowly carinate; nine triangular narrow complanate chambers; aperture radiate

Locality. Stratton's marl pit, near Mullica Hill, in the shell layers of the green marl. Very common. Timber Creek, in the yellow limestone. Abundant. Teredo bed. Not abundant.

CRISTELLARIA WETHERELLII Jones, sp.

Marginulina sp. Sowerby. 1834. Trans. Geol. Soc. Lond. ser. 2. v. 135. pl. ix. fig. 12.

Marginulina wetherellii Jones. 1854. Morris's Cat. Brit. Foss. 37.

Marginulina wetherellii Parker and Jones. 1859. Ann. and Mag. Nat. Hist. ser. 3. iv. 350.

Marginulina fragaria Gümbel. 1868. Abhandl. d. K. bayer. Akad. d. Wiss. II. cl x. 635. pl. i. fig. 58. a, b, c.

Cristellaria asperula Id. Ibid. pl. i. fig. 65. a, b.

Cristellaria arcuata Hantken. 1875. Mittheil. Jahrb. d. K. ung. geol. Anstalt. iv. 51. pl. v. fig. 10.

Cristellaria fragaria Id Ibid. 53. pl. vi. figs. 1-3.

Cristellaria wetherellii Brady. 1884. Report on Foram. H. M. S. Challenger. Zool. ix. 537. pl. cxiv. fig. 14.

"The test of *Cristellaria wetherellii* is usually pod-like or crosier-shaped, but varies greatly in length and in the relative development of the spiral and linear portions. It is, however, always more or less spiral at the commencement, and almost invariably exhibits considerable lateral compression; therefore, so far as such characters are of any distinctive value, it belongs to the genus *Cristellaria* rather than to *Marginulina*. The salient feature of the species is its peculiar surface-decoration, consisting of closely-set raised tubercles, which take the place of continuous limbate septal lines. These are often, but not invariably, connected by slight, oblique, longitudinal costæ, most apparent on the earlier portions of the shell."—Brady. loc. cit.

Locality. Stratton's marl pit, near Mullica Hill, in the shell layers of the green marl. Quite rare. Timber Creek, teredo bed. Abundant.

Sub-family POLYMORPHININÆ

POLYMORPHINA d'Orbigny.

POLYMORPHINA ANGUSTA Egger.

Polymorphina (*Globulina*) *fusiformis* Roemer. 1838. Neues Jahrb. für Min. 386. pl. iii. fig. 37.

Polymorphina liassica Strickland. 1845. Quart. Journ. Geol. Soc. ii. 30. fig. b.

Globulina leopolitana Reuss. 1850. Haidinger's Abhandl. iv. 44. pl. v. fig. 11.

Grammostomum turis Ehrenberg. 1854. Mikrogeologie. pl. xxvi. fig. 19.

Globulina acuta Reuss. 1855. Sitzungsb. d. K. Akad. Wissensch. xviii. 51. pl. vi. fig. 62.

Polymorphina (*Globulina*) *angusta* Egger. 1857. Neues Jahrb. für Min. 290. pl. xiii. figs. 13, 15.

Polymorphina subrhombica Reuss. 1861. Sitzungsb. d K. Akad. Wiss. Wien. xliv. 339. pl. vii. fig. 3

Polymorphina lanceolata (pars) Reuss. 1870. Sitzungsb. d. K. Akad. Wiss. Wien. lxii. 487. No. 12; Schlicht. 1870. Foram. Pietzpuhl. pl. xxxi. figs. 2, 3, 4.

Polymorphina gracilis Id. Ibid. Schlicht. 1870. Foram. Pietzpuhl. 486. No. 7. pl. xxxi. figs. 34, 45.

Polymorphina fusiformis (pars) Brady, Parker, and Jones. 1870. Trans. Linn. Soc Lond. xxvii. 219. pl. xxxix. fig. 5. a, b, c.

Polymorphina angusta Brady. 1884. Report on Foram. H. M. S. Challenger. Zool. ix. 563. pl. lxxi. figs. 1–3.

Test elongate, subcylindrical, tapering at both extremities.

Chambers few, from three to four, oblique, somewhat convex, septal lines but slightly depressed. Surface smooth.

Locality. Stratton's marl pit, near Mullica Hill, in the shell layers of the green marl. Rare.

POLYMORPHINA COMMUNIS d'Orbigny.

Polymorphina (*Guttulina*) *communis* d'Orbigny. 1826. Ann. Sci. Nat. vii. 226. No. 15. pl. 12. figs. 1–4; Modèle No. 62.

Guttulina vitrea d'Orbigny. 1839. Foram. Cuba. 128. pl. ii. figs. 1–3

Polymorphina (*Guttulina*) *communis* Roemer. 1838. Neues Jahrb. für Min. Jahr. 1838. 385. pl. iii. fig. 29.

Polymorphina glomerata Roemer. 1841. Verstein. norddeutsch. Kreid. pt. 2. 19. pl. xv. fig. 19.

Polymorphina glomerata Reuss. 1845. Verstein. böhm. Kreid. pt. 1. 40. pl. xii. fig. 32.

Guttulina communis Reuss. 1845. In Geinitz's Grundriss der Verstein. 669. pl. xxiv. fig. 82.

Guttulina communis d'Orbigny. 1846. Foram. Foss. Vien. 224. pl. xiii. figs. 6–8.

Guttulina irregularis d'Orbigny. Id. Ibid. 226. pl. xiii. figs. 9, 10.

Globulina discreta Reuss. 1849. Denkschr. Mathem-Natur. Cl. K. Akad. Wissensch. i. 378. pl. xlviii. fig. 10.

Guttulina cretacea Alth. 1849. Haidinger's Abhandl. iii. 262. pl. xiii. fig. 14.

Guttulina semiplana Reuss. 1851. Deutsch d. geol. Gesell. iii. 82. pl. vi fig. 48

Guttulina semiplana Bornemann. 1855. Zeitsch. deutsch. geol. Gesell. vii. 344.

Polymorphina (*Guttulina*) *communis* Egger. 1857. Neues Jahrb. für Min. Jahr. 1857. 288. pl. xiii. figs. 16–18.

Polymorphina (*Guttulina*) *lata* Egger. Ibid. 228. pl. xiii. figs. 22–24.

Guttalina fissurata Stache. 1865. Novara Exped. Geol. i. pt. 2. 263. pl. xxiv. fig. 10.

Guttalina obliquata Id. Ibid. 264. pl. xxiv. fig. 11.

Polymorphina problema, var. *deltoidea* Reuss. 1866. Denkschr. d. mathem. Natur. Cl. Akad. Wiss. xxv. 154. pl. iv. fig. 8.

Polymorphina semiplana Reuss. 1870. Sitzungsb. d. K. Akad. Wiss. Wien. lxii. 488 No. 16; Schlicht. 1870. Foram. Pietzpuhl. pl. xxvii. figs. 22–33.

Polymorphina problema, var *communis* Id. Ibid. 487. No. 15; Schlicht. pl. xxx. figs. 13–16.

Polymorphina communis Brady, Parker, and Jones. 1870. Trans. Linn. Soc. Lond. xxvii. 224. pl. xxxix. fig. 10. a, b.

Polymorphina communis Brady. 1884. Report on Foram. H. M. S. Challenger. Zool. ix. 568. pl. lxxii. fig. 19.

Test ovate, gibbous, more or less compressed at three sides; anterior extremity acute; posterior obtuse and rounded. Chambers few, oblique, inflated. Sutures depressed. Surface smooth. Aperture circular, coronate.

Locality. Stratton's marl pit, near Mullica Hill, in the shell layers of the green marl. Rare. Timber Creek, in the yellow limestone. Rare. Teredo bed. Abundant. In the gryphæa bed. Rare.

POLYMORPHINA COMPRESSA d'Orbigny.

Fistulose form.

Polymorpha corcula spinosa Soldani. 1791. Testaceographia ac Zoophytographia. i. pt. 2. pls. 109–111.

Guttulina damæcornis Reuss. 1845. Verst. böhm. Kreid. 1te Abtheil. 40. pl. xiii. fig. 85.

Guttulina tubulosa d'Orbigny. 1846. Foram. Foss. Vien. 228. pl. xiii figs. 15, 16.

Aulostomella pediculus Alth. 1849. Haidinger's Naturw. Abhandl. iii. 264. pl. xiii. fig. 17.

Globulina horrida Reuss. 1850. Ibid. iv. 43. pl. iv. fig. 8.

Polymorphina fistulosa Williamson. 1858. Rec. Foram. Gt. Brit. 72. pl. vi. fig. 150.

Polymorphina lactea, var. *tubulosa* Parker and Jones. 1865. Phil. Trans. Roy. Soc. clv. 362. pl. xiii. fig. 52. a–d.

Polymorphina orbignii (pars) Brady, Parker, and Jones. 1870. Trans. Linn. Soc. Lond. xxvii. 244. pl. xlii. fig. 38. d.

Polymorphina compressa (Fistulose form) Brady. 1884. Report on Foram. H. M. S. Challenger. Zool. ix. 566. pl. lxxiii. fig. 17.

Polymorphina compressa Whiteaves. 1887. Trans. Roy. Soc. Can. iv. 114.

Test free or adherent. General form variable; oval, oblong, or compressed. Terminal segments developing numerous irregular expansions and tubular outgrowths.

Locality. Stratton's marl pit, near Mullica Hill, in the shell layers of the green marl. Rare. Timber Creek, in the yellow limestone. Quite rare.

POLYMORPHINA LACTEA Walker and Jacob, sp.

"*Serpula tenuis ovalis lævis*" Walker and Boys. 1784. Test. Min. 2. pl. i. fig. 5.

Serpula lactea Walker and Jacob. 1798 (fide Kanmacher). Adams' Essays. 2d ed. 634. pl. xxiv. fig. 4.

Vermiculum lacteum Montagu. 1803. Test. Brit. 522.

Guttulina plancii d'Orbigny. 1839. Voyage dans l'Amér. Mérid. 60. pl. i. fig. 5.

Polymorphina lactea Macgillivray. 1843. Moll. Aberd. 320.

Arethusa lactea Thorpe. 1844. Brit. Mar. Conch. 233.

Globulina lachryma Reuss. 1845. Verstein. böhm. Kreid. pt. 1. 40, 110. pl. xiii. fig. 83; Alth. 1849. Haidinger's Abhandl. iii. 263. pl. xiii. fig. 16; Reuss. 1850. Ibid. iv. 43. pl. v. fig. 9.

Pyrulina ovulum Ehrenberg. 1854. Mikrogeologie. pl. xxxi. figs. 35, 36.

Polymorphina muensteri Reuss. 1855. Sitzungsb. d. K. Akad. Wiss. Wien. xviii. 249. pl. viii. fig. 80.

Globulina roemeri Id. Ibid. 245. pl. vi. fig. 63.

Polymorphina lactea, *typica* (pars) Williamson. 1858. Rec. Foram. Gt. Brit. 71. pl. vi. fig. 147.

Polymorphina lactea. var. *communis* Id. Ibid. 72. pl. vi. figs. 153–155.

Polymorphina lactea Dawson. 1859. Can. Nat. and Geologist. iv. 28. figs. 2, 3.

Guttulina diluta Bornemann. 1860. Zeitschr. deutsch. geol. Gesellsch xii. 160. pl. vi. fig. 11.

Globulina lacrima Reuss. 1861. Sitzungsb. d. K. Akad. Wiss. Wien. xliv. 318, 338.

Polymorphina lactea Brady, Parker, and Jones. 1870. (Monograph of *Polymorphina*) Trans. Linn. Soc. Lond. xxvii. 213. pl. xxxix. fig. 1. a–c.

Polymorphina lactea Brady. 1884. Report on Foram. H. M. S. Challenger. Zool. ix. 559. pl. lxxi. (typical) fig. 11 ; (var.) fig. 14.

Polymorphina lactea Whiteaves. 1887. Trans. Roy. Soc. Can. iv. 114.

Fistulose form.

"*Polymorpha corcula spinosa*" Soldani. 1791. Testaceographia. i. pt. 2. 114. pl. cix. fig. I, etc.

Misilus aquatifer Montfort. 1808. Conch. Systém. i. 294. 74e genre.

Apiopterina d'Orbigni Zborzewski. 1834. Nouv. Mém. Soc. Imp. Nat. Moscou. iii. 311. pl. xxviii. fig. 2. b.

Polomorphina lactea (fistulose form) Brady. 1884. Report on Foram. H. M. S. Challenger. Zool. ix. 560. pl. lxxiii. fig. 14.

Test ovate, gibbous, slightly unsymmetrical; anterior extremity acute; posterior obtuse, rounded. Chambers few, oblong, oblique, somewhat inflated. Sutures depressed. Surface smooth. Aperture simple, circular or oval, radiate.

Locality. Timber Creek, in the yellow limestone. Rare. Teredo bed. Quite abundant.

The fistulose forms are those having a hollow, like a pipe or reed. They are occasionally found in the teredo bed.

POLYMORPHINA OBLONGA d'Orbigny.

Polymorphina oblonga d'Orbigny. 1846. Foram. Foss. Vien. 232. pl. xxii. figs. 29–31.

Polymorphina uvæformis Reuss. 1855. Zeitschr. d. deutsch. geol. Gesellsch. vii. 289. fig. 5.

Polymorphina guttata Reuss. 1870. Sitzungsb. d. K. Akad. Wiss. Wien. lxii. 487 ; Schlicht. 1870. Foram. Pietzpuhl. pl. xxx. figs. 25–32.

Polymorphina oblonga Brady. 1884. Report on Foram. H. M. S. Challenger. Zool. ix. 569. pl. lxxiii. figs. 2–4.

Test elongate, smooth, anteriorly acuminate, posteriorly obtuse, compressed; with six oblong chambers, convex; sutures excavate, aperture radiate.

Locality. Timber Creek, in the teredo bed. Rare.

POLYMORPHINA PROBLEMA d'Orbigny.

Polymorphina (*Guttulina*) *problema* d'Orbigny. 1826. Ann. Sci. Nat. vii. 266. No. 14; Modèle No. 61.

Polymorphina (*Guttulina*) *crassatina* Münster. 1838 (fide Roemer). Neues Jahrb. für Min. Jahr. 1838. 385. pl. iii. fig. 30.

Polymorphina (*Guttulina*) *spicæformis* Roemer. 1838. Ibid. 386. pl. iii. fig. 31.

Guttulina problema Reuss. 1845. In Geinitz's Grundriss der Verstein. 669. pl. xxiv. fig. 83.

Guttulina problema d'Orbigny. 1846. Foram. Foss. Vien. 224. pl. xii. figs. 26–28.

Guttulina austriaca Id. Ibid. 223. pl. xii. figs. 23–25.

Guttulina cretacea Alth. 1849. Haidinger's Naturw. Abhandl. iii. 262. pl. xiii. fig. 14.

Polymorphina uvula Ehrenberg. 1854. Mikrogeologie. pl. xxvi. fig. 28.

Polymorphina uvula Egger. 1857. Neues Jahrb. für Min. Jahr. 1857. 285. pl. x. figs. 26–29.

Guttulina cretacea Reuss. 1861. Sitzungsb. d. K. Akad. Wiss. Wien. xliv. 319, 339.

Guttulina rotundata Reuss. 1864. Sitzungsb. d. K. Akad. Wiss. Wien. l. 469. pl. iii. fig. 4.

Guttulina pusilla Stache. 1865. Novara Exped. Geol. i. pt. 2. 265. pl. xxiv. fig. 12.

Polymorphina problema Parker, Jones, and Brady. 1866. Monogr. Crag Foram. pl. i. fig. 64.

Polymorphina problema Brady, Parker, and Jones. 1870. Trans. Linn. Soc. Lond. xxvii. 225. pl. xxxix. fig. 11. a, b.

Polymorphina problema Brady. 1884. Report Foram. H. M. S. Challenger. Zool. ix. 568. pl. lxxii. fig. 20; pl. lxxiii. fig. 1.

Test oblong, ovate, irregular. Chambers numerous, much inflated, and separated by deep sutures; sometimes arranged triserially, but more frequently crowded together irregularly; orifice round, radiate; surface smooth.

Locality. Stratton's marl pit, near Mullica Hill, in the shell layers of the green marl. Rare. Timber Creek, in the teredo bed. Abundant.

POLYMORPHINA REGULARIS von Münster.

Polymorphina regularis von Münster. 1838 (fide Roemer). Neues Jahrb. für Min. Jahr. 1838. 385. pl. 3. fig. 21.

Polymorphina regularis Philippi. 1844. Beiträge zur Kenntniss d. Tertiärverst. nordwest. Deutsch. 41, 70.

Polymorphina regularis Karsten. 1849. Verzeichn. d. Rostock. Verst. a. d. Sternberger Gestein. 8.

Polymorphina regularis Reuss. 1855. Sitzungsb. d. K. Akad. Wiss. Wien. xviii. 247. pl. vii. figs. 70–73; l. 38. pl. iii. figs. 11, 12. pl. iv. fig. i.

Polymorphina regularis, var. *Nysti* Reuss. 1863. Bullet. de l'Acad. roy. de Belgique. xv. 162. pl. iii. fig. 42.

Polymorphina lingulata Stache. 1865. Novara Reise i. 2te Abtheil. Paläont. von Neu-Seeland. 255. pl. 24. fig. i.

Polymorphina marsupium Stache. 1865. Novara Reise. i. 2te Abtheil. Paläont. von Neu-Seeland. 258. pl. xxiv. fig. 5.

Polymorphina dispar Stache. 1865. Novara Reise. i. 2te Abtheil. Paläont. von Neu-Seeland. 261. pl. xxiv. fig. 8.

Polymorphina gigantea Stache. 1865. Novara Reise. i. 2te Abtheil. Paläont. von Neu-Seeland. 262. pl. xxiv. fig. 9.

Polymorphina regularis Brady, Parker, and Jones. 1870. Trans. Linn. Soc. Lond. xxvii. 229. pl. xl. fig. 13. a–c.

Test oblong, irregularly biconvex, broadest in the upper half, tapering towards both base and apex; periphery thin and produced but not carinate. Septal lines marked by slight constriction. Chambers numerous, long, oblique. Surface smooth.

Locality. Stratton's marl pit, near Mullica Hill, in the shell layers of the green marl. Common. Timber Creek, in the teredo bed. Not common.

POLYMORPHINA ROTUNDATA Bornemann, sp.

Guttulina rotundata Bornemann. 1855. Zeitschr. d. deutsch. geol. Gesellsch. vii. 346. pl. xi. p. xviii. fig. 3.

Guttulina incurva Id. Ibid. 345. pl. xvii. fig. 6.

Guttulina fracta Id. Ibid. 344. pl. xvii. fig. 4.

Guttulina dimorpha Id. Ibid. 345. pl. xvii. fig. 5.

Polymorphina rotunda Reuss. 1866. Denkschr. mathem. Naturw. Cl. K. Akad. Wissensch. xxv. 153.

Polymorphina tenera Karrer. 1868. Sitzungsb. d. K. Akad. Wiss. Wien. lviii. 174. pl. iv. fig. 9.

Rostrolina sp. Schlicht. 1870. Foram. Pietzpuhl. 72. No. 412. pl. xxvi. figs. 13–15.

Polymorphina rotunda Reuss. 1870. Sitzungsb. d. K. Akad. Wiss. Wien. lxii. 487. No. 14; Schlicht. op. cit. pl. xxvi. figs. 13–15; pl. xxviii. figs. 1–5; pl. xxx. figs. 33–40.

Polymorphina turgida Id. Ibid. 487. No. 10; Schlicht. pl. xxviii. figs. 6–10; pl. xxix. figs. 1–5.

Polymorphina rotundata Brady, Parker, and Jones. 1870. Trans. Linn. Soc. Lond. xxvii. 234. pl. xl. fig. 19. a–e, and woodcuts.

Polymorphina rotundata Brady. 1884. Report on Foram. H. M. S. Challenger. Zool. ix. 570. pl. lxxiii. figs. 5–8.

Test oblong, ovoid, subcylindrical, gibbous, rounded at the base, more or less produced at the apex. Chambers numerous, broad. Septa marked by lines only, neither constricted nor excavated. Orifice simple, round, oval, or radiate. Surface smooth.

Locality. Timber Creek, in the teredo bed. Rare.

GLOBIGERINIDÆ.

GLOBIGERINA d'Orbigny.

GLOBIGERINA CRETACEA d'Orbigny.

Globigerina cretacea d'Orbigny. 1840. Mém. Soc. Geol. France. iv. 34. pl. iii. figs. 12–14.

Globigerina foveolata (pars) Ehrenberg. 1854. Mikrogeologie. pl. xxiv. fig. 49.

Globigerina libani Ehrenberg. Ibid. pl. xxv. fig. 30.

Planulina pachyderma Id. Ibid. pl. xxv. fig. 31.

Rotalia pertusa Id. Ibid. pl. xxiv. fig. 41.

Rotalia aspera Id. Ibid. pl. xxvii. figs. 57, 58; pl. xxviii. fig. 42; pl. xxxi. fig. 44.

Rotalia globulosa Id. Ibid. pl. xxvii. fig. 60; pl. xxviii. figs. 40, 41; pl. xxxi. figs. 40, 41, 43.

Rotalia densa Id. Ibid. pl. xxvii. fig. 62.

Rotalia quaterna Id. Ibid. pl. xxvii. fig. 53; pl. xxviii. fig. 34.

Rotalia rosa Id. Ibid. pl. xxvii. fig. 54.

Rotalia pachyomphala Id. Ibid. pl. xxvii. fig. 55.

Rotalia tracheotetras Id. Ibid. pl. xxvii. fig. 35.

Rotalia perforata Id. Ibid. pl. xxviii. fig. 36; pl. xxix. fig. 2.

Rotalia protacmæa Id. Ibid. pl. xxviii. fig. 37.

Rotalia laxa Id. Ibid. pl. xxviii. fig. 38; pl. xxix. fig. 1; pl. xxxi. fig. 42.

Rotalia centralis Id. Ibid. pl. xxviii. fig. 39.

Globigerina cretacea G. M. Dawson. 1875. Report Geol. and Resources, 49th Parallel British N. A. Boundary Comm. 79.

Globigerina cretacea Brady. 1879. Quart. Journ. Micr. Sci. xix. n. s. 285.

Globigerina cretacea Schwager. 1883. Palæontographica. xli. fig. 13. a–d.

Globigerina cretacea Brady. 1884. Report on Foram. H. M. S. Challenger. Zool. ix. 596. pl. lxxxiii. Fossil specimens. fig. 11. a–c.

Globigerina cretacea Woodward and Thomas. 1885. 13th Ann. Report. Geol. Nat. Hist. Survey Minn. 171. pl. iii. figs. 14–16; ii. fig. 19.

Globigerina cretacea Tyrrell. 1890. Trans. Roy. Soc. Can. vii. 114.

Globigerina cretacea Woodward and Thomas. 1893. Final Report Geol. Nat. Hist. Survey Minn. iii. 41. pl. D. figs. 18, 19.

Test suborbicular, compressed, rugose aculeate, spire obtuse, with three distinct convolutions, five to seven segments, depressed spheroidal, sutures excavated, aperture large in the umbilicus.

Locality. Stratton's marl pit, near Mullica Hill, in the shell layers of the green marl. Common. Timber Creek, in the yellow limestone. Rare. Teredo bed. Common.

ROTALIDÆ.

DISCORBINA Parker and Jones.

DISCORBINA BERTHELOTI d'Orbigny, sp.

Rosalina bertheloti d'Orbigny. 1839. Foram. Canaries. 135. pl. i. figs. 28–30.

Discorbina bertheloti Brady. 1864. Trans. Linn. Soc. Lond. xxiv. 469. pl. xlviii. fig. 10. a, b.

Discorbina turbo, var. *parisiensis*, subvar. *berthelotiana* Parker and Jones. 1865. Phil. Trans. clv. 387. pl. xvi. figs. 26, 27.

Discorbina berthelotiana Goës. 1882. Kongl. Sv. Vet. Akad. xix. 107. pl. viii. figs. 266–268.

Discorbina bertheloti Brady. 1884. Report on Foram. H. M. S. Challenger. Zool. ix. 650. pl. lxxxix. figs. 10–12.

Discorbina bertheloti Woodward. 1887. Journ. N. Y. Mic. Soc. iii. 17.

Test very depressed, carinate, punctate; spire short, with two convolutions, partly with depressed chambers, carinate, arcuate, margin limbate.

Locality. Timber Creek, in the yellow limestone. Quite rare. Teredo bed. Rare.

TRUNCATULINA d'Orbigny.

TRUNCATULINA HAIDINGERII d'Orbigny, sp.

Rotalina haidingerii d'Orbigny. 1846. Foram. Foss. Vien. 154. pl. vii. figs. 7–9.

Rotalina ehrenbergii Bailey. 1851. Smithsonian Contrib. ii. art. 3. 10. figs. 11–13.

Rotalia brueckneri Reuss. 1855. Zeitschr. d. deutsch. geol. Gesellsch. vii. 273. pl. ix. fig. 7.

Rotalia propinqua Reuss. 1855. Sitzungsb. d. K. Akad. Wiss. Wien. xviii. 241. pl. iv. fig. 53. a, b. c.

Rotalia hemisphærica Reuss. 1861. Sitzungsb. d. K. Akad. Wiss. Wien. xliv. 314. pl. ii. fig. 5.

Rotalia lenticula Reuss. 1863. Sitzungsb. d. K. Akad. Wiss. Wien. xlvi. 35. pl. x. fig. 3.

Planorbulina haidingeri Brady. 1864. Trans. Linn. Soc. Lond. xxiv. 469. pl. xlviii. fig. 11.

Planorbulina farcta var. *haidingerii* Parker and Jones. 1865. Phil. Trans. clv. 382. pl. xvi. fig. 22. a, b.

Truncatulina haidingeri Reuss. 1867. Sitzungsb. d. K. Akad. Wiss. Wien. lv. 28.

Pulvinulina haidingeri Hantken. 1875. Mittheil. Jahrbuch. d. Kön. ungar. geol. Anstalt. iv. 77. pl. xv. fig. 10. a, b.

Truncatulina haidingerii Brady. 1884. Report on Foram. H. M. S. Challenger. Zool. ix. 663. pl. xcv. fig. 7. a–c.

Test orbicular, trochiform, punctate, below somewhat convex, umbilicate, spire conical; with four narrow convolutions, externally carinate, with six chambers arcuate above, below narrowly triangular, convex.

Locality. Timber Creek, in the yellow limestone. Rare.

TRUNCATULINA LOBATULA Walker and Jacob, sp.

"*Nautilus spiralis lobatus*, etc." Walker and Boys. 1784. Test. Min. 20. pl. iii. fig. 71.

"*Hammoniæ tuberculatæ*, etc." Soldani. 1789. Testaceographia. i. pt. 1. 58. pl. xlv. figs. ii. kk, ll, mm.

Nautilus lobatulus Walker and Jacob. 1798. Adam's Essays, Kanmacher's Ed. 642. pl. xiv. fig. 36.

Serpula lobatula Montagu. 1803. Test. Brit. 515. Suppl. 160.

Truncatulina tuberculata d'Orbigny. 1826. Ann. Sci. Nat. vii. 279. No. 1; Modèle No. 37.

Truncatulina lobatula d'Orbigny. 1839. Foram. Canaries. 134. pl. ii. figs. 22–24.

Discorbis lobatulus Macgillivray. 1843. Moll. Anim. Aberd. 34.

Truncatulina lobatula d'Orbigny. 1846. Foram. Foss. Vien. 168. pl. ix. figs. 18–23.

Truncatulina boveana d'Orbigny. 1846. Foram. Foss. Vien. 169. pl. ix. figs. 24–26.

Anomalina variolaria d'Orbigny. 1846. Foram. Foss. Vien. 170. pl. ix. figs. 27–29.

Truncatulina communis Reuss. 1855. Sitzungsb. d. K. Akad. Wiss. Wien. xviii. 242. pl. v. fig. 56.

Truncatulina lobatula Parker and Jones. 1857. Ann. and Mag. Nat. Hist. ser. 2. xix. 293. pl. x. figs. 17–21.

Truncatulina lobatula Williamson. 1858. Rec. Foram. Gt. Br. 59. pl. v. figs. 121–123.

Truncatulina varians Reuss. 1860. Sitzungsb. d. K. Akad. Wiss. Wien. xlii. 359. pl. ii. fig. 12. a, b.

Truncatulina lobatula Dawson. 1860. Can. Nat. and Geologist. v. 192. fig. 50.

Rotalia polyraphes Reuss. 1861. Sitzungsb. d. K. Akad. Wiss, Wien. xliv. 337.

Rosalina bosqueti Reuss. 1861. Sitzungsb. d. K. Akad. Wiss. Wien. xliv. 337. pl. iii. fig. 1.

Truncatulina dekayi Reuss. 1861. Sitzungsb. d. K. Akad. Wiss. Wien. xliv. 338. pl. vii. fig. 6. a, b, c.

Planorbulina farcta, var. (*Truncatulina*) *lobatula* Parker and Jones. 1865. Phil. Trans. clv. 381. pl. xiv. figs. 3–6; pl. xvi. figs. 18–20.

Truncatulina lobatula Jones, Parker, and Brady. 1866. Monogr. Foram. Crag. pl. ii. figs. 4–10; pl. iv. fig. 18.

Truncatulina (*lobulata ? d'Orb.*) Hilgard and Hopkins. 1878. Reclamation of the Alluvial Basin of the Miss. River. 43. pl. ii. fig. 65.

Truncatulina lobatula Brady. 1884. Report on Foram. H. M. S. Challenger. Zool. ix. 660. pl. xcii. fig. 10; pl. xciii. figs. 1, 4, 5; pl. cxv. figs. 4, 5.

Truncatulina lobatula Whiteaves. 1887. Trans. Roy. Soc. Can. iv. 115.

Test suborbiculate, depressed, slightly punctate, beneath somewhat convex; with three convolutions, externally angular; with seven chambers, arcuate above, irregular somewhat convex.

Locality. Stratton's marl pit, near Mullica Hill, in the shell layers of the green marl. Rare. Timber Creek, in the yellow limestone. Common. Teredo bed. Common. New Egypt, in the green marl. Rare.

TRUNCATULINA UNGERIANA d'Orbigny, sp.

Rotalina ungeriana d'Orbigny. 1846. Foram. Foss. Vien. 157. pl. viii. figs. 16–18.

Rotalina granosa Reuss. 1851. Zeitschr. d. deutsch. geol. Gesellsch. iii. 75. pl. v. fig. 36.

Rotalina semipunctata Bailey. 1851. Smithsonian Contrib. ii. art. 3. 11. figs. 17–19.

Rotalia roemeri Reuss. 1855. Sitzungsb. d. K. Akad. Wiss. Wien. xviii. 240. pl. iv. fig. 52.

Rotalia mortoni Reuss. 1861. Sitzungsb. d. K. Akad. Wiss. Wien. xliv. 337. pl. viii. fig. 1.

Planorbulina ungeriana Brady. 1864. Trans. Linn. Soc. Lond. xxiv. 469. pl. xlviii. fig. 12, *Planorbulina farcta,* var. *ungeriana* Parker and Jones. 1865. Phil. Trans. clv. 382. pl. xvi. figs. 23–25.

Truncatulina ungeriana Reuss. 1866. Denkschr. d. K. Akad. Wiss. Wien. xxv. 161. No. 10.

Truncatulina ungeriana Brady. 1884. Report on Foram. H. M. S. Challenger. Zool. ix. 664. pl. xciv. fig. 9. a, b, c.

Test orbicular, depressed, punctate, below somewhat convex, umbilicate, spire complanate, granulose, with three wide convolutions, externally acutely carinate ; with eleven chambers, above triangular, below flexuose, somewhat convex, externally margined (limbate), the last convex.

Locality. Stratton's marl pit, near Mullica Hill, in the shell layers of the green marl. Rare. Timber Creek, in the yellow limestone and the teredo bed. Rare.

ANOMALINA d'Orbigny.

ANOMALINA AMMONOIDES Reuss, sp.

Rosalina ammonoides Reuss. 1845. Verstein. böhm. Kreid. pt. 1.36. pl. xiii. fig. 66; pl. viii. fig. 53.

Rosalina ammonoides Reuss. 1850. Haidinger's Naturw. Abhandl. iv. 36. pl. iv. fig. 2.

Rotalia ammonoides Reuss. 1861. Sitzungsb. d. K. Akad. Wiss. Wien. xliv. 337.

Nonionina bathyomphala Reuss. 1862. Sitzungsb. d. K. Akad. Wiss. Wien. xlvi. 95. pl. xiii. fig. 1. a, b.

Rosalina weinkauffi Reuss. 1863. Sitzungsb. d K. Akad. Wiss. Wien. xlviii. 68. pl. viii. fig. 97.

Rosalina maorica Stache. 1864. Novara Exped. geol. i. 282. pl. xxiv. fig. 32.

Rosalina orbiculus Stache. 1864. Novara Exped. geol. i. 285. pl. xxiv. fig. 34.

Planorbulina ammonoides Parker and Jones. 1865. Phil. Trans. clv. 379.

Rotalia capitata Gümbel. 1868. Abhandl. d. K. bayer. Akad. Wiss. II. cl. x. 653. pl. ii. fig. 92.

Rotalia ammonoides Reuss. 1870. Sitzungsb. d. K. bayer. Akad. Wiss. 283.

Planorbulina (*Anomalina*) *ammonoides* Jones and Parker. 1872. Quart. Journ. Geol Soc. xxviii. 106; table 109.

Planorbulina ammonoides Reuss. 1874. Das Elbthälgebirge in Sachsen. ii. 114. pl. xxiii. fig. 9.

Anomalina ammonoides Brady. 1884. Report on Foram. H. M. S. Challenger. Zool. ix. 672. pl. xciv. figs. 2, 3.

Anomalina ammonoides Tyrrell. 1890. Trans. Roy. Soc. Can. vii. 114.

Anomalina ammonoides Woodward and Thomas. 1893. Final Report Geol. Nat. Hist. Survey Minn. iii. 44. pl. D. figs. 28, 29, 30.

"The nautiloid aspect of the test is perhaps a more constant and more noticeable feature of *Anomalina ammonoides* than of any other member of the group. The shell is generally much compressed, and nearly equally convex on the two sides; the peripheral edge is round, and the aperture is placed almost symmetrically in the median line. In certain characters, however, the species betrays a tendency to variation. Some specimens are depressed at both umbilici (fig. 3), others are umbonate at one or both (fig. 2); sometimes the earlier convolutions are visible to a nearly equal extent on both faces; sometimes, on the other hand, they are nearly involute on the inferior side, though the shell retains its bilateral symmetry, as in Reuss's figure. The coarse perforation of the shell-wall is usually more conspicuous on the inferior than on the superior face."—Brady, loc. cit.

Locality. Bruere's pits, Crosswick's Creek, lower marl bed, in the gray marl. Rare. Timber Creek, in the teredo bed. Quite abundant.

PULVINULINA Parker and Jones.

PULVINULINA MICHELINIANA d'Orbigny.

Rotalina truncatulinoides d'Orbigny. 1839. Foram. Canaries. 132. pl. ii. figs. 25–27.

Rotalina micheliniana d'Orbigny. 1840. Mém. Soc. géol. France. iv. 31. pl. iii. figs. 1–3.

Rotalina nitida Reuss. 1845. Böhm. Kreide. 1. 35. pl. xii. figs. 8, 20, 31; pl. viii. fig. 52.

Rotalia micheliniana Reuss. 1861. Sitzungsb. d. K. Akad. Wiss. Wien. xliv. 336.

Discorbina micheliniana Reuss. 1865. Sitzungsb. d. K. Akad. Wiss. Wien. liii. 455. No. 1.

Pulvinulina repanda, var. *menardii*, sub var. *micheliniana* Parker and Jones. 1865. Phil. Trans. clv. 396. pl. xiv. fig. 16; pl. xvi. figs. 41–43.

Pulvinulina micheliniana Owen. 1867. Journ. Linn. Soc. Lond. ix. Zool. 148. pl. v. fig. 17.

Pulvinulina normanni Karrer. 1878. For. Luzon. Bolet. Comis. Mapa geol. d. Españo. 7. 2, 24. pl. F. fig. 10.

Pulvinulina micheliniana Brady. 1879. Quart. Journ. Micr. Sci. xix. n. s. 80.

Pulvinulina micheliniana Goës. 1882. Köngl. Sv. Vet. Akad. xix. 114. pl. viii. figs. 296–298.

Pulvinulina micheliniana Brady. 1884. Report on Foram. H. M. S. Challenger. Zool. ix. 694. pl. civ. figs. 1, 2.

Test orbicular convex, smooth, above plane, beneath convex-conical, margin carinate, spire complanate, with three convolutions, feebly distinct; with angular chambers, subcomplanate, umbilicus convex, aperture elongate.

Locality. Timber Creek, in the yellow limestone. Rare.

PULVINULINA KARSTENI Reuss, sp.

Rotalia karsteni Reuss. 1855. Zeitschr. d. deutsch. geol. Gesellsch. vii. 273. pl. ix. fig. 6.

Rotalia karsteni Reuss. 1861. Sitzungsb. xliv. 337.

Pulvinulina karsteni Brady. 1864. Trans. Linn. Soc. Lond. xxiv. 470. pl. xlviii. fig. 15.

Pulvinulina repanda, var. *karsteni* Parker and Jones. 1865. Phil. Trans. clv. 396. pl. xiv. figs. 14, 15, 17; pl. xvi. figs. 38–40.

Pulvinulina karsteni Brady. 1884. Report on Foram. H. M. S. Challenger. Zool. ix. 698. pl. cv. figs. 8, 9.

Pulvinulina karsteni Whiteaves. 1887. Trans. Roy. Soc. Can. iv. 115.

"The test of *Pulvinulina karsteni*, in well-developed specimens, is nearly round and very regularly built, convex on both faces, and with obtuse subangular periphery. It is composed of from three to four convolutions, the final circuit having about seven chambers; the sutures, which are marked by fine lines on the superior face, are somewhat depressed on the inferior; and the margin of the test on the inferior side has a limbate border."—Brady, loc. cit.

Locality. Timber Creek, in the yellow limestone. Common. Teredo bed. Not common.

ROTALIA Lamarck.

ROTALIA ORBICULARIS d'Orbigny.

Rotalia (*Gyroidina*) *orbicularis* d'Orbigny. 1826. Ann. Sci. Nat. vii. 278. No. 1; Modèle No. 13.

Rotalia orbicularis Brady. 1864. Trans. Linn. Soc. Lond. xxiv. 470. pl. xlviii. fig. 16.

Rotalia beccarii, var. *orbicularis* Parker and Jones. 1865. Phil. Trans. clv. 389. pl. xvi. fig. 34.

Rotalia orbicularis Terquem. 1882. Mém. Soc. géol. France. ser. 3. ii. Mém. III. 60. pl. iv. figs. 1–3.

Rotalia orbicularis Brady. 1884. Report on Foram. H. M. S. Challenger. Zool. ix. 706. pl. cvii. fig. 5; pl. cxv. fig. 6.

"The test of *Rotalia orbicularis* is approximately plano-convex, the superior face being flat or only slightly arched, the inferior convex and more or less excavated at the umbilicus, and the peripheral edge subangular. It is isomorphous with *Truncatulina lobatula* in the Planorbuline series, and forms a connecting link between *Rotalia beccarii* and *Rotalia soldanii.*—Brady, loc. cit."

Locality. Timber Creek, in the yellow limestone. Rare. Teredo bed. Quite common.

NUMMULINIDÆ.

Sub-Family NUMMULITINÆ.

OPERCULINA d'Orbigny.

OPERCULINA COMPLANATA, var. GRANULOSA Leymerie.

Amphistegina fleuriausi d'Orbigny. 1826. Ann. Sci. Nat. vii. 304. No. 7. (name only, fide Reuss).

Operculina granulosa Leymerie. 1846. Mém. Soc. géol. France. ser. 2. i. 359. pl. xiii. fig. 12. a, b.

Amphistegina fleuriausi Reuss. 1861. Sitzungsb. d. K. Akad. Wiss. Wien. xliv. 308. pl. i. figs. 10–12.

Operculina irregularis Reuss. 1864. Denkschr. d. K. Acad. Wiss. Wien. xxiii. 10. pl. i. figs. 17, 18.

Operculina granulata Gümbel. 1868. Abhandl. d. K. bayer. Akad. d. Wiss. II. Cl. x. 663. pl. ii. fig. 111. a, b.

Operculina complanata, var. *granulosa* Brady. 1884. Report on Foram. H. M. S. Challenger. Zool. ix. 743. pl. cxii. figs. 6, 7, 9, 10.

Operculina complanata, var. *granulosa* Woodward and Thomas. 1885. Geol. Nat. Hist. Survey Minn. 13th Ann. Report. 176. pl. ii. fig. 36.

Operculina complanata, var. *granulosa* Woodward and Thomas. 1893. Final Report Geol. Nat. Hist. Survey Minn. iii. 46. pl. E. fig. 38.

Test. It is uniformly smaller than *complanata;* its partitions, which form a slight relief upon the surface of the very thin shell which encloses the convolutions, are proportionally more approximate. This species is very flat, and is made up of three or four spirals. It carries on its surface on each side a number of fine granulations, which are found irregularly distributed upon the little elevations which correspond to the interior partitions. These projecting points, scarce upon the last convolutions, are found crowded towards the centre in many individuals.

Locality. Stratton's marl pit, near Mullica Hill, in the shell layers of the green marl. Rare. New Egypt, in the green marl. Rare.

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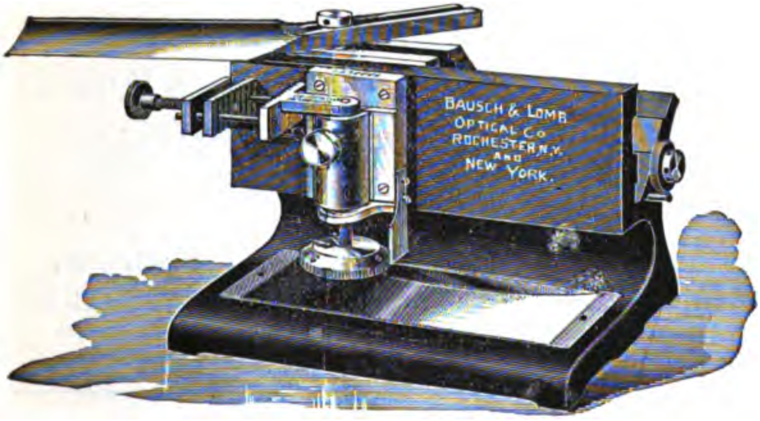

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OF THE

NEW-YORK MICROSCOPICAL SOCIETY

VOLUME XI.

INC. 1877.

NEW-YORK:
PUBLISHED FOR THE SOCIETY,
QUARTERLY.

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Vol. XI. JANUARY, 1895. No. 1.

10,412

JOURNAL

OF THE

New-York Microscopical Society

EDITED BY

REV. J. L. ZABRISKIE,

28 REGENT PLACE, FLATBUSH STATION, BROOKLYN, N. Y.

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New-York:

PUBLISHED FOR THE SOCIETY,

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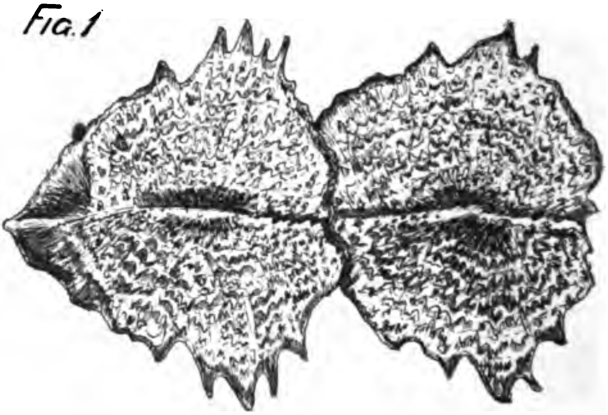

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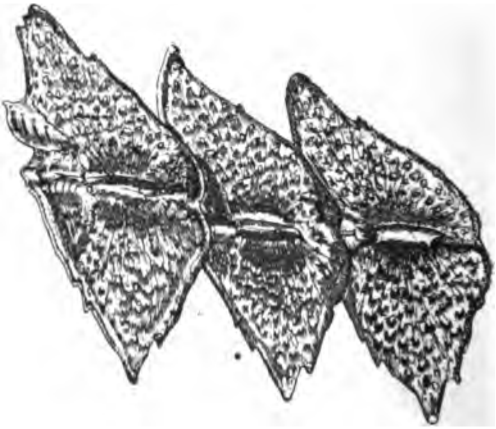

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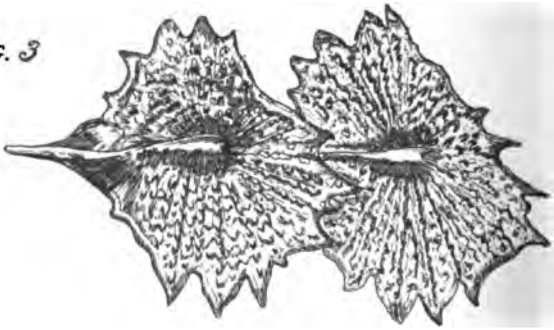
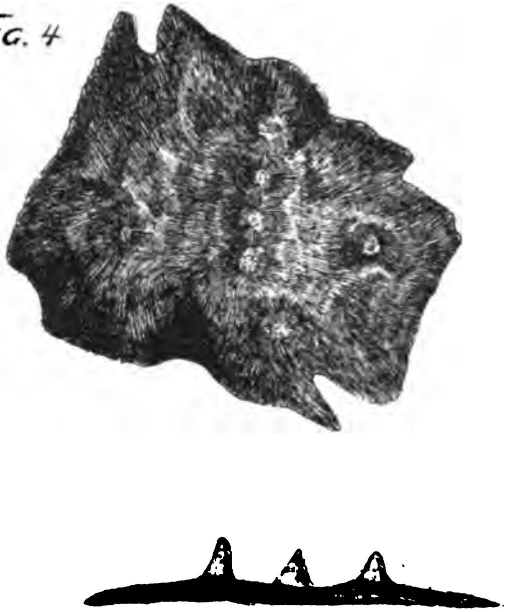


ARMOR OF THE STURGEON.

FIG. 4



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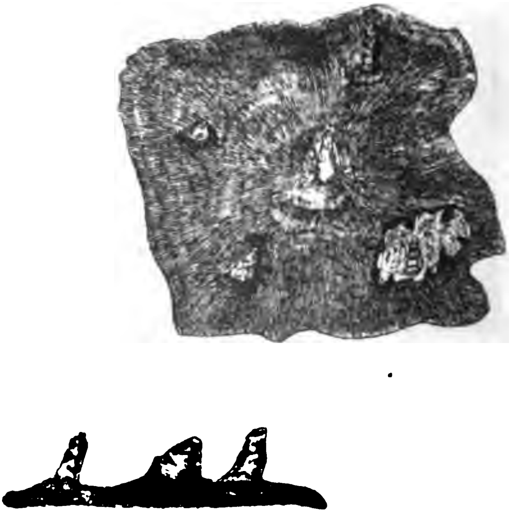

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Fig. 6

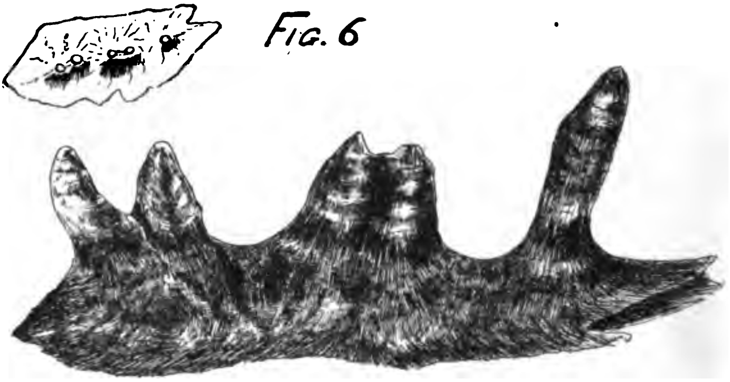

Fig. 7

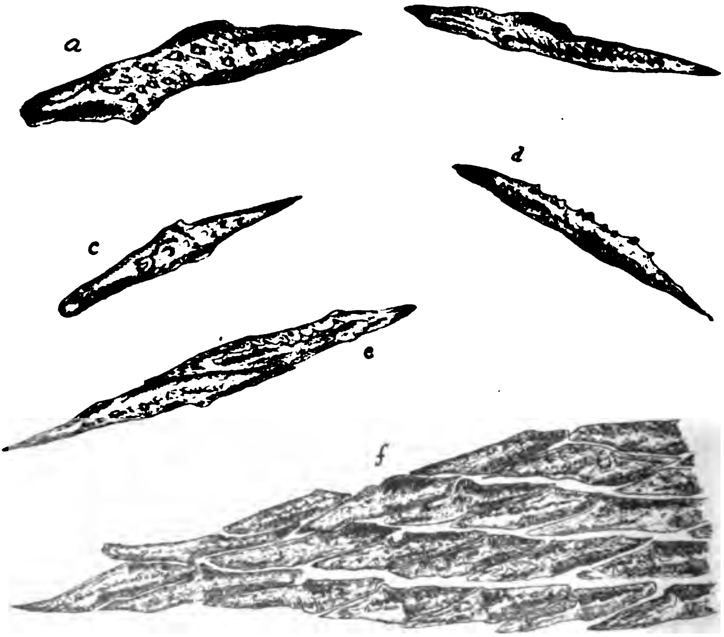

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FIG. 8

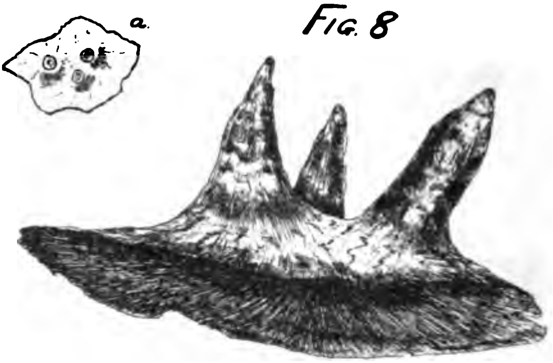
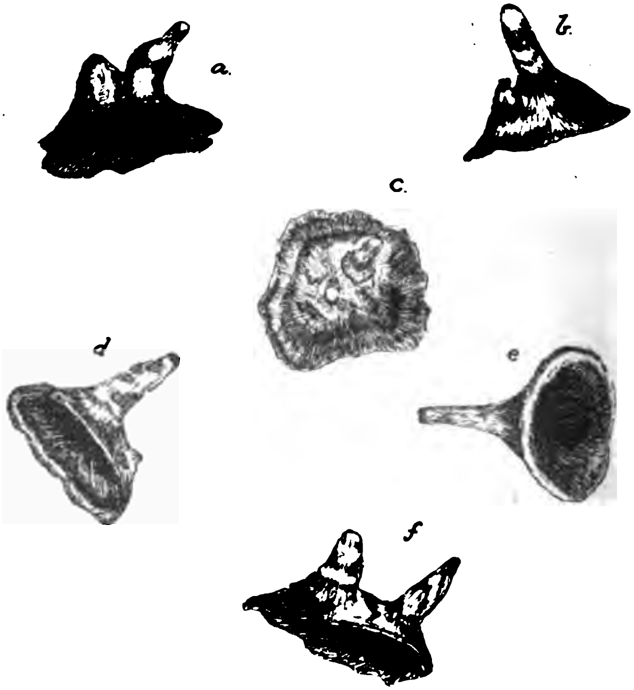


FIG. 9



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JOURNAL

OF THE

NEW-YORK MICROSCOPICAL SOCIETY.

VOL. XI. JANUARY, 1895. No. 1.

THE DERMAL ARMOR OF THE STURGEON.

BY GEORGE WILLIAM KOSMAK.

(*Read January 4th, 1895.*)

I.—INTRODUCTION.

The Sturgeon has commanded the interest and attention of almost every nation living near the oceans, great rivers and seas of our northern hemisphere, for several centuries, as history informs us. For many hundred years its economic importance as a factor in the food supply of many peoples, has made it so well known, from the practical standpoint, that Science in our own century has not neglected to make this member of the class *Fishes* the subject of theortical investigation as well.

Explanation of Plates 45, 46, 47, 48.

These figures are from pen-drawings of scutes and derm-denticles which were isolated from the surrounding dermal tissue by KHO. They were taken from Sturgeon about two feet in length, and in drawing them care was taken to maintain the relative proportions, excepting in the case of scutes (Figs. 1, 2, 3), and the derm-denticles (Figs. 4-9).—the latter being enlarged about five times as much as the former. For the actual sizes refer to the text.

PLATE 45. FIG. 1.—Body-scutes from the middle of the dorsal row. FIG. 2.—Scutes from one of the lateral rows. FIG. 3.—Scutes from the ventral rows.

PLATE 46. FIGS. 4, 5.—Derm-denticles from the dorsal faces. These should be compared with FIG. 9. Attention is directed to the ganoid character of the former, and the placoid character of the latter. Each figure shows the object in plan and elevation.

PLATE 47. FIG. 6.—A derm-denticle from one of the lateral faces, shown in plan and elevation. FIG. 7.—Derm-denticles from the tail region. *A*, *b*, *c*, *d*, *e* are isolated specimens, to more clearly show their form and the character of the spines, while *f* shows the arrangement *in situ*.

PLATE 48. FIG. 8.—A derm-denticle from one of the lateral faces. FIG. 9.—Derm-denticles of a placoid type, from the ventral face.

The Sturgeon (*Acipenser*) is generally found in salt water, but, like other members of the finny tribe, may live in fresh water for a time, when it ascends the larger rivers during the Spring for the purpose of depositing its spawn, returning to the sea at the end of the season. Some forms always inhabit fresh water, such as those of our own Great Lakes, and the allied *Scaphirrhynchus* of the Mississippi Valley. The principal fishing grounds of the world for the Sturgeon are the Baltic, Black and Caspian Seas in Europe and the Great Lakes, and the eastern coast of the United States from Maine to Florida, in America. The main products of the industry are the flesh, fresh or smoked, the roe, from which "Caviar" is made, and "isinglass," the dried "air" or swim-bladder.

The growth of the industry has, as in many other cases, largely depleted its numbers,—so, in order to augment the natural increase, various methods of artifically hatching the Sturgeon have been tried, but without material success, as parasitic fungi and other, apparently insurmountable difficulties, prevented the development of the larger proportion of eggs set out. Only within the past two years has a method been devised, after many experiments, by means of which the young fish could be successfully hatched out in numbers sufficient to give the plan a practical and therefore commercial value.*

This evening's paper may more properly be classed as theoretical, and from this standpoint, Biology and Palæontology have honored *Acipenser* and its allies with considerable study and attention.

The Sturgeon occupies a singular position in the scale of Vertebrate development:—a retrograde Ganoid, intermediate between the Sharks below, and the other Ganoids (Gar-pike, etc.), above it, and having some of the characteristic features of each. The scales and other integumentary structures aid in placing our type in this intermediate plane; some, as we shall see later, are of a distinct placoid (shark) form, others are closely related to such ganoid structures as we find in the Gar-pike. In order to better comprehend the structure and relationship of the Sturgeon's dermal armor to the other fish types, it will be well to preface our description of the subject proper by a brief account of fish scales in general, their development and structure.

---

* The results of this investigation are embodied in a report to the U. S. Fish Commission, by Dr. Bashford Dean, of Columbia College.

II.—FISH-SCALES IN GENERAL.

The protective function of the skin of Fishes is greatly enhanced by a system of armoring, made up of various elements of a limy, or horn-like consistency, which may be classed as scales, scutes and derm-denticles. Though these undergo many modifications in form and distribution in the different groups of Fishes, yet they are all derived from the same source, the dermal layer of the skin, with the epidermis taking only a secondary part. We may, however, recognize four pretty constant divisions of scales proper:—cycloid, ctenoid, ganoid and placoid. These terms were employed by Louis Agassiz as a basis for the classification of fishes themselves;—but more rational standards have since been adopted, and his survive as descriptive terms of the scales alone.

The term scales is usually applied to various bone or horn-like structures, of which it is possible to distinguish three somewhat widely differing conditions in Fishes: in the one form we have the skin itself very soft and covered by scales in the proper sense of the word, instances of which we find in the Cod, the Perch and other Teleosts. The other extreme presents a condition of complete nakedness of the skin, as in most Eels, the Lampreys and all Fishes provided with well developed electric organs. A stage midway between these two includes several interesting types which we cannot class in either one or the other of the groups just mentioned; these forms are the Sharks, the Rays and the Sturgeon.

We must recur for a moment to the method of classification of Fishes of Louis Agassiz, based on the form of their scales. It has already been noted, how in time his method became obsolete: it shared the fate of all like systems, which, based on the modifications in structure of one organ, are necessarily artificial. Yet his work was of great importance, for it opened up a new field of research, by the study and comparison of fossil with living forms. The lines between the kinds of scales cannot be sharply drawn, but one merges into the other. We must base our descriptions, therefore, on the generalities of each group.

(*a.*) *Placoid* scales consist each of a basal plate embedded in the skin, with one or more derm denticles projecting beyond the surface. Such a condition gives us the "shagreen" of Sharks.

(*b.*) *Ganoid* scales are hard and bony, covered by a thin layer of enamel [(?) ganoin], and generally rhomboidal, seldom rounded. They are usually arranged in oblique rows and overlap after the manner of roof-tiles. They are typical in the Gar-pike.

(*c.*) *Cycloid* scales have no covering of enamel; the hinder ends are smooth, and being free, overlap one or more of the succeeding scales; the outer surface is striated in two directions, one set rather coarse, radiating from the center towards the posterior margin, the other, much finer in character, concentric and parallel to the margin.

(*d.*) *Ctenoid* scales are, as a rule, thicker than those last mentioned, and provided with spinous teeth on the hinder edges, of one or all the layers of which the scale is composed.

All scales, scutes and derm-denticles as included in this series are developed as horny or calcareous elements from a dermal papilla, and later become enclosed in a kind of dermal pocket, as best represented in the Teleosts. We can here insert a brief description of these structures as they occur in the characteristic fish types.

Passing by *Cyclostomes*, which have a naked skin without any traces of scales, we come to the *Elasmobranchs*, and in this sub-class shall take the Sharks as a type. In each "placoid" scale can be distinguished a fundamental part, the *basal plate*, and an apical part, the spine or *denticle*. The basal plates are usually rounded or rhomboidal and arranged in rows diagonal to the long axis of the body; each plate is separated from its neighbors by narrow stretches of skin, which allow for the development of new rows of plates between the rows of the old ones during the growth of the animal. Connective tissue fibres are attached to their lower surfaces from the deeper parts of the derma. The number of spines on each plate varies, some have only one, which may be simple or divided into three smaller points at the free end (*Scyllium*): in others, again, there may be several in one line, with the largest in the center, or they may be scattered over the entire plate.

The under surface of each plate is perforated at the center by a canal which continues into the denticle, and there expands and forms a pulp cavity, with branches ramifying into the substance of the spine.

Oscar Hertwig has verified the very close correspondence in the histological development between these placoid scales and the maxillary teeth in Sharks. The hard covering of the denticle, from its origin, must be looked upon as enamel, and by the agency of polarized light its prismatic structure has been demonstrated, while the interior agrees with the dentine of higher Vertebrates both in chemical and morphological characters. The basal plate still stands in need of considerable explanation as to its true origin and structure. Hertwig considers it as true ossified connective tissue ("verknöchertes bindegewebe"), or in analogy with the teeth of Mammals as "cement." Neither dentine tubules or cells are here present.

The development of the placoid scale has been most closely studied by Hertwig (1876) and Klaatsch (1890) and the results of their researches, very much abbreviated, furnish us with the necessary data for our discussion.—Before there is any trace of scale formation, the integument of *Selachians* agrees closely with that of *Cyclostomes*, and at this stage may be looked upon as representing an ancestral condition. The first indication of a scale formation is a local upheaval of the epidermis, caused by a dome-shaped growth in that part of the derma, called by Hertwig, the "germ-layer," which is richly supplied with blood-vessels and assumes the most important role in the formation of placoid scales.

The dermal papilla grows larger and a differentiation then occurs of its component elements into a mass which presses against the overlying epidermis in the form of a blunted cone, and another which spreads out parallel to the surface in the outer dermal layer. The growth of the two parts continues and results in the pre-formation in cells of the later scale:—the conical part indicating the spine, and the flat mass, the basal plate. The formation of the hard parts now begins: the basal epithelial cells secrete an enamel cap, which begins at the point and extends gradually over the entire spine. The containing cells now take up calcareous matter and form a homogeneous mass,—the dentine. Some cells remain in the pulp-cavity, others are surrounded by the substance of the dentine, but still communicate by processes with the central cavity, and thus originate the dentine tubules.

When the spine is completed, the process of dentine-formation extends over the flat portion of the scale-germ and produces the basal plate. This power of secretion is embodied in certain dermal elements, derived from the germ-layer. The enamel covered spine now pushes its way outward, until the neck is on a plane with the inner border of the epidermis, the process of enamel secretion having also been continued to that point. The dentine of the interior has become very much thickened, with consequent increase in the number of the tubules: the upper part of the pulp-cavity being itself so narrowed as to resemble one of them. A complete denticle now results.

The placoid organs are differentiated in various ways: those in the mouth are specialized into maxillary teeth, those on the body become protective in function. The spinous part may become modified and changed into numerous small or a few large spines. The arrangement of the scales may be greatly altered by the dropping out of some and the formation of others at different spots; and this large number and constant regeneration of the placoid scales characterizes the present Selachians.

Although relatively they approach very closely the original primitive fish type, we must consider the living Selachians as survivors of a group which has branched off and developed along a definite, unwavering line. We cannot therefore look upon their dermal armor as the prototype of all other fish scales. In this connection it is important to state that the number of scales is far less in young than in adult sharks, and we may therefore recur to a previous condition with fewer scales than in living forms, through which Sharks have passed. This is probably the primitive type of all such structures, and we shall come back to it later.

We must next consider the scales of Ganoids. Several widely differing forms are included in this group of Fishes, established by Louis Agassiz and further defined and elaborated by Johann Müller. The member selected as a type for the discussion of the Ganoid scale is the Gar-pike (*Lepidosteus osseous*). The results here noted are those of the latest researches, of Klaatsch in 1890, and Nickerson, 1893.

Ganoid scales in our type are rhomboidal, arranged in oblique rows, and each so placed that its hinder margins slightly overlap the succeeding ones. In very young specimens, the relations of the scales to each other are different:—on the ventral side they are smaller, and more circular, and between the rows are stretches of skin increasing in breadth towards the ventral median line, so that there are spaces totally devoid of scales in the young, which are fully covered in the adult. At the beginning of their formation we find in the outer layer of the dermis a thin sheet of calcareous matter, completely separated from the epidermis by several layers of dermal secreting cells (scleroblasts). Where blood-vessels pierce this layer, no secretion can take place, and openings through the scale at such places are thus formed. As the scale increases in size and thickness (from both outer and inner surfaces, but more particularly from the inner), "scleroblasts" become enclosed in it, with radiating and intercommunicating canaliculi, and the edges of adjacent scales come close together and overlap, by reason of a slight elevation of the posterior end during the early development. On the lower side connective tissue fibres from the deeper derma also become enclosed, and extending from one scale to another allow of a flexible connection and articulation. Around the posterior margin of the scales of young Gars are scattered a number of sharp spines, of which there is hardly any trace in the adult fish. They originate independently from cells over the basal plate, under the basement membrane of the epidermis, the inner end joins the basal plate below, and as this grows in thickness, becomes incorporated with it. The cap is secreted by dermal, not epidermal cells, and cannot therefore be classed as enamel, but has been called "ganoin."

Comparing these facts with those of the foregoing type, we notice the following relations: In Selachians, the spine appears first, the basal plate follows; in *Lepidosteus* the plate is formed first, the spine secondarily. In Selachians we always find a less number, though persistent spines; in *Lepidosteus*, a greater number, but transient. The spines are essentially alike, with the exception of the cap, which is enamel in the first group, ganoin in the other. A striking change has therefore become manifest in the transition from the *placoid* to the *ganoid* type. The basal plate has become the important factor; it is formed independently of the spine, which comes on later, but soon disappears.

Hertwig derives the scales of *Lepidosteus* from fusion of numerous basal plates of the Selachian type, each spine representing a primitive placoid scale. There may be some truth in this, but yet his conclusion seems imaginative when we consider the large number and irregular arrangement of the spines on a single *Lepidosteus* scale. A more probable theory may be put forward:—going back to a common prototype, we can consider the scale-formative processes, diverging along two lines, in one all the energies of the dermal secreting cells were devoted to the construction of a spine with a basal plate as secondary, in the other a plate is formed primarily which corresponds to the main body and mass of the other basal plate, with a covering of "*ganoin.*" In the latter type, spines are formed independently of the underlying basal plate, and the hereditary tendency which results in their formation, may also be accepted as the cause of their disappearance, in the same manner as fish-like gill slits appear during the embryonic life of the chick, only to disappear with advancing growth.

We have now come to the discussion of the highest orders of Fishes:—the Teleosts. In a previous classification were noted cycloid and ctenoid scales. Considering their many variations, nearly all Teleost scales can be traced to one or the other, or to an intermediate type, of these two forms. Examined *in situ* they are seen to consist mostly of thin plates of ossified or horny material, embedded at one end in connective tissue pouches of the derma, the other end being free and overlapping parts of one or more of the immediately succeeding scales. They are arranged in rows diagonal to the long axis of the body. We can dismiss the development of the Teleost scale, with the general statement that they represent a plate of two layers, an outer osseous, and an inner of connective tissue, which has been incorporated during growth to form lamina.

The Teleost scale as it stands alone, is rather puzzling. To properly understand its position, we must attempt to derive it from, or at least correlate it with, the forms we have already described:—the *placoid* and *ganoid* types. It is believed that the Teleost scale tallies with the basal plate of the *placoid*, especially of the upper part. Other proofs are also at hand to strengthen this assumption ; there are, in fact, numerous examples of deviations and anomalies from the standard. Thus we have Teleost scales with well-developed spines, one or more in number, and it has been asserted that the centrum is the seat of a former spine. The relation to *placoid* scales has thus been established, but the connection with the *ganoid* form is not so definite. Lepidosteus scales up to a certain stage of their development, may be looked upon as an intermediate form between Teleosts and typical Ganoids, though in the course of evolution they have undergone many specializations. Certain conditions were then discovered in "*Amia calva*,"—the survivor of a large family of fossil Ganoids,—which greatly aided the establishment of final definite relations between Ganoid and Teleost. This fish probably stood very close to the prototype of all Teleosts, but was supplied in addition with many other features of the Ganoids. The scale of *Amia* is made up of two layers, an outer, containing osseous elements, and inner layer without these, but laminated. Like conditions are found in Teleosts. Then Palæontology furnishes the link by which the rhomboidal Ganoid are finally connected with the Teleost scales by bringing to light intermediate forms of Ganoids with cycloid scales and Teleosts with ganoidal scales.

Let us now compare the three types which have been examined: Selachian, Ganoids and Teleosts.—We notice first of all the general arrangement of all scales in oblique rows. [Rows of *scutes*, such as are possessed by the Sturgeon, are in general parallel to the long axis of the body.]

The Teleost derives only the superficial part of the basal plate from that of the *placoid* scale ; there are wanting, therefore, the deeper layer and usually the spines. The under layer is of a secondary formation.

For the growth of new scales in Selachians sufficient space has been provided between those already developed. In Teleosts, similar conditions occur only in the early ontogenetic stages.

The *ganoid* scale, lying almost parallel to the body surface, is destined to grow most in thickness, continually taking up parts of the cutis and incorporating them in its substance, thus securing a more intimate connection with the connective tissue of the skin. The growth along the edges proportional to the growth of the animal, is very small. Compare with this the Teleost scale which is imbedded at one end in a pocket of the derma, and therefore necessitates a growth at the free margin only. It fits loosely in its pocket, for it does not incorporate any connective tissue with it, but grows by a complicated secretive process.

Though the relations are more difficult to establish, it is evident that the typical Teleost scale approaches nearer to a Ganoid than a Selachian form. Klaatsch (Morph. Jahrb., Vol. XVI.) has constructed a diagrammatic scheme which greatly simplifies the comprehension of these facts. By this it will be seen that the various forms of modern fish scales are the terminal points of lines radiating from a common center, which may be represented by a Selachian-like prototype:—" rhomboid plates in rows from the center of each a spine arising." This condition persists to a certain extent in modern Selachians, the increase in number of spines and the thickening of the basal plates being secondary and later modifications. The spine may be reduced and the basal plates be extended horizontally, until one touches the other. Thus we have a transition from a primitive *placoid* to a primitive *ganoid* scale. A further thickening and definite rhomboidal form now ensues, with close connection of individual scales by ligaments and an overlapping of the margins. This last type then breaks up into many smaller divisions, with two main branches, one represented by *Lepidosteus*, the other by *Acipenser*. In a totally different direction a series branches off from the prototype of the Ganoid scale, which furnishes the link between Ganoids and Teleosts, in *Amia* and others before noted, and which leads to the *cycloid* and *ctenoid* types. These remarks conclude the introduction to our subject proper. It is hoped that they have been made clear enough for the better understanding of what follows.

III.—THE SCALES OF THE STURGEON.

Gunther places the Sturgeons proper and their related forms in the Sub-order Chondrostei, which he divides into two families: Acipenseridæ, or Sturgeons proper, including the genera, *Acipenser* and *Scaphirhynchus*, and Polyondontidæ, with the genus *Polyodon*. The Acipenseridæ form a well-defined family, geologically the youngest of the Ganoids, which have halted in the process of evolution at an early stage. This is well shown in the peculiarities of their armor as it is studied in detail. The descriptions were taken from two specimens of *Acipenser sturio*, of a little more than 50 cm. in length (as these would best present the conditions between young and adult forms), and with them have been compared young fish of 14 and 19 cm., and a large specimen of about 1.75 metres.

Upon examining the surface of the body, we notice that it is divided into five faces, which on cross-section cause it to present a pentagonal outline. The five main rows of scutes form the angles of these faces, and the intervening stretches of skin are studded with many derm-denticles. The faces we may designate as right and left dorsal, right and left lateral, and ventral. At any given section, except at the extremities of the body, they are of almost equal breadth, the lateral perhaps a trifle wider. The dorsal crest of the body falling away anteriorly, causes the dorsal faces to merge into one on top of the head. The lateral faces extend from the front edge of the operculum, narrowing posteriorly, to the point of insertion of the caudal fin. The ventral face forms the flat under surface of the body, runs forward under the rostrum, but back of the anal fin is merely wide enough to accommodate the post-anal plates. This peculiar contour and outline presented by a cross-section of the body differs greatly from that ordinarily found in Fishes, where the element of form is an ellipse, with the long and short axes in varying relations to each other.

In our description of the dermal armor it is well to commence with the structure and arrangement of the large scutes found disposed in five rows, each running almost the length of the body.

A.—DORSAL SCUTES.

Extending from the last of the fused head-covering bones to the dorsal fin is a row of eleven large scutes, which number is constant for all of the species. The external surface is made up of two faces, inclined in the first at an angle of about 135°, but decreasing in next to the last, to an angle of about 90°. The first is the largest, the others become smaller in proportion to the decrease in body surface, towards the tail. The anterior ones are broader than long, the posterior ones the reverse. The outline is irregular: the sides are deeply serrated, the front is produced forward into a blunt spine, the hinder part is notched at the middle line. The skin unites with the scute and covers the serrated part, and also extends over the articulation between two neighboring scutes, which is formed by a ridge and spine on the front end of each fitting into a notch on the hinder margin of the one preceding. This construction allows of movement in all directions.

The surfaces of the scutes are studded with radiating rows of small, irregular, spinous projections, those of one row connecting with some of an adjacent row by little ridges. The junction of the two faces of each scute produces a well-marked crest of varying outline. Three parts can be distinguished in this:—an anterior part, which begins at the point where the skin which takes part in the articulation with the previous spine is attached. In the first scale this part of the crest is continuous with that of the fused head scale in front of it, and in the last scale, from the nature of its faces, it is absent altogether. Serrations commence in front, decreasing in size towards the central spine, and probably result from the fused spines as found on the other parts of the surface. I have noticed that these serrations are most pronounced in the medium sized specimens. The middle part of the crest, constituting its most prominent feature, is formed by a spine, with its point directed caudad. In the young the point is sharper and smoother than in older forms, but in all it grows more marked as we pass caudally. The posterior portion of the ridge runs from the spine to the hinder margin of the scute, and slightly overhangs the median notch. The serrations here are stronger and deeper than in the anterior part and probably result from the same cause; in the last scute it is necessarily absent, and in the next a mere trace. The entire ridge undergoes several changes during the growth of the fish; it is more regular in the youngest forms, that is, the serrations are not so extensive or pronounced, and the anterior and posterior parts are of almost equal and constant length, as opposed to older specimens, where we find the anterior part the larger. In the fully developed adult the crest and its spine have almost totally disappeared;—this fact will be spoken of again later on.

The scutes are all of nearly the same outline in young, but become greatly changed in adult forms, as can be seen by comparing the plates. These variations are undoubtedly due to mechanical agencies:—lateral movements of the fish would tend to the compression of the hinder ends, as the foreshortened central scutes plainly show. This same movement also probably gave the middle scutes their steeper pitch, as in younger forms the angle is more uniform.

Before leaving this main row of dorsal scutes, the modifications that occur around the last one must be noticed. Instead of remaining a single plate, it may become divided in the median line, or there may be one or more separate smaller plates intercolated between it and the preceding one, which are flat, rhomboidal and studded with projections similar to those on the other plates. The spine of this last of the dorsal row of scutes articulates with the fulcrum of the dorsal fin, on each side of which is found a row of spinous, rhomboidal, flat plates, of a later development than the others. Posterior to the dorsal fin are two irregular rows of plates, decreasing in size towards the tail, crowded more closely together with the growth of the animal, until they become fused in the adult; the last of these are narrow and elongated, pointed in the back and notched in front, overlap and articulate, and continue as the fulcra of the dorsal margin of the tail.

B.—LATERAL SCUTES.

These vary in number on both sides of the body in the same individual;—generally twenty-eight or thirty. As in the dorsal scutes, this is a zoological count, and morphologically we may include two others, which are fused with the head scutes and function as part of the secondary shoulder-girdle. They are counted therefore from this point into the base of the tail. Like the dorsal their surfaces are made up of two faces, inclined at a large angle to each other in the greater number, but decreasing near the tail. The central crest is not so pronounced, yet the spine is much more developed and sharper than in the dorsal scutes. In shape they are not so irregular as the others: the majority about twice as long as broad, with the last few about the same dimensions in both directions. In outline they are nearly smooth, rounded at the upper, pointed, and with one or two serrations at the lower end; the anterior margin is very smooth, with large projection and notch over the middle line of the scute; the flattened part underlying the scute immediately in front, forms with the aid of a notch* in the otherwise quite smooth anterior edge, a skin-covered articulation. The entire edge is much thinner than the rest of the scute and is covered by skin. We must in conclusion mention also the spinous projections on the surfaces, and the general forward inclination of the scutes.

C.—Ventral Scutes.

We can differentiate two main rows of these, extending from the pectoral to the anal fins; there are generally one or two more on the one side than on the other, so that they number from nine to eleven on either side. Corresponding to the pinkish-white color of the belly, they also appear light in tint (owing to the lighter pigment in the overlying epidermis). The two faces unite in a central spine and crest, the anterior end of which is continued with the margin of the scute into a long spur, which, with a notch in the hinder end of the next scale, forms an articulation. In the last scute this spur is not always covered by the scute in front, but projects outward from the middle line; this occurs generally in that row which contains the least number of scutes. The last members on each side articulate with the fulcra of the anal fins. Posterior to the spines, the junction of the faces is not angular, but rounded, and therefore no crest is present. The margins are deeply serrated, thin, and covered by skin, without such spiny projections as are found in radiating lines from the central spine, on the remainder of the scale.

Anterior to those we have just discussed are four others which from their position and general features we can class morphologically as ventral scutes. They form the lower part of the supplementary dermal shoulder girdle, and are closely connected with those of the upper side and form the boundary of the gill-opening on its one side. The outer two articulate by a socket with the pectoral fin, the other two may be considered analogous to a sternum.

Between anus and tail we have a series of scutes similar to those directly above them on the dorsal side. Directly in front of the anus we have the pre-anal plates, four or more in

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[* This cannot be made out in the posterior scutes.]

number, loosely set in the skin and not appearing in the youngest specimens examined, because the ventral scutes come so close together as to leave no room for their growth. The post-anal plates number four or five, with the two nearest the anus generally free in young forms, but closely articulated or even fused, in adults (especially the last two). [In one young fish was noticed a larger central plate with the others grouped around it.] Back of all these is a scute; flat in front, with projections which fit into spaces left between the hinder ends of the last post-anal plates. The posterior end of this scute is continued into a process which articulates with the fulcrum of the ventral fin. On each side of this fin we have a number of flat plates, increasing in size posteriorly; the two immediately behind the fin unite, and the last one very elongated, articulates with the caudal fin.

D.—DERM-DENTICLES.

Between the five rows of large scutes just considered, are scattered through the skin a large number of the so-called basal plates furnished with projecting spines, the denticles. Their arrangement is not very regular;—if the body be slightly twisted in a direction across the long axis of the animal, the skin falls into a great number of small wrinkles, each of which contains an irregular row of derm-denticles. On those parts of the head where no scutes occur they are also thickly scattered. Specimens from various parts of the body were isolated from the surrounding tissue by KHO and studied, to detect any differences in form and structure, due to location. Microscopic sections were also prepared for an intended study of histological characters; but the nature of the material made the cutting difficult, even after trying various methods of decalcifying.

Generally speaking, the derm-denticle consists of a basal plate, with one or more spines arising from it, not formed independently, but as part of the plate. The spine is elongated, solid, and projects beyond the surface of the skin. On the dorsal surface are comparatively large rhomboidal plates, bearing short blunt spines arranged in various ways:—

I have observed plates with a group of spines in the center and one at each corner, some with three or four spines in a row, others with them scattered irregularly over the surface. On the lateral faces we find two kinds of derm structures:—one resembling the basal plates of the dorsal faces but more irregular in outline and not so large or containing so many blunt spines, the other has a smaller but thicker basal plate hollowed out on the lower surface, with a corresponding rounded upper face, bearing two, sometimes three or four pointed spines in a row, the central one always the larger. These latter plates are nearly elliptical in outline and found irregularly scattered among the others. (Fig. 8.) On the ventral surface we also have two varieties, but the larger plates are more rhomboidal, and furnished with a less number of blunt spines than those of the other faces. The other kind agree with the rounded ones of the lateral faces, except that the spines may be larger and more pointed. (Fig. 9.)

On the sides of the tail we find some curious conditions. Here we have plates somewhat elongated, though their quadrangular shape can be plainly made out; thickest in the middle, tapering towards the long ends. They measure from three-eighths to one-half an inch in length, and about one-sixteenth at the widest part. Their edges come close together but do not overlap; they form rows, which in one direction are parallel to the dorsal edge of the tail, and in the other are inclined to it. Diagonally across each scale, connecting the two lesser angles, is a spinous ridge, the constituent spines of which are seldom regularly disposed. (Fig. 7.)

On examining sections cut from this region, I could not distinguish any histological difference between this form and the other derm-denticles of the body—all seem to be a homogeneous mass without Haversian canals, or other such structures. Having thus briefly examined the various parts which make up the dermal armor of the Sturgeon, we must compare the results with the conditions found in other fish types and endeavor to show from what forms it has been derived and to which most nearly related, that is as far as the integument is concerned.

Before comparing it with other fishes, however, a few relations between the scales of the Sturgeon itself, must be noted. If specimens of the young and adult be contrasted, several striking differences will at once become apparent. The scutes of the young fish lie closer together and overlap each other more than in the adult; the spines are more pronounced and smoother in outline and their points sharper than in larger forms,—in fact, in the fully grown Sturgeon they disappear altogether. The other projections on the body of the scute, are indicated in the young by lines radiating from the large central spine; in the largest specimens these have become very marked, but blunter, and connected with each other by ridges, so as to give the entire surface a very rough and pitted appearance. It seems that all the secretive energies of the young scute are directed to the formation of a sharp spine, while in the adult where this has disappeared the process of ossification is merely employed to thicken the scute. Judging by a taste prevalent in the members of the human species, the flesh of the Sturgeon must also prove an agreeable article of diet to the fellow inhabitants of its native lakes and rivers. The full-grown adult forms are too large and swift to be sought after by any but their human enemies, but the young would more easily become the prey of other fishes were it not for the protection afforded by the development of the recurved spines on the scutes, which would undoubtedly prove an unwholesome morsel for even a piscine gullet. We thus see how nature has protected the young Sturgeon against its enemies by passive means of defence in the form of very sharp spines; in the adult fish, which is not subjected to such dangers, they are no longer necessary and are gradually absorbed.

IV.—CONCLUSION.

A resumé of the discussion relating to the derivation of all fish scales from a common prototype was given on a preceding page, the results noted being mainly those of Hermann Klaatsch. In his diagrammatic scheme the scales of *Lepidosteus* and *Acipenser* are placed at the ends of two co-ordinate branches, both arising from a type which had thickened, rhomboidal scales, closely connected by ligaments and overlapping. He considers *Acipenser* as presenting a secondary reduction of the scales which in the ancestral *Palæoniscidæ* served as a highly protective dermal armor.

The Sturgeon having thus been given a position on a genealogical tree of scale forms, as it were, let us see by what factors, as presented by the study of the various scutes and derm-denticles of our type, we can link *Acipenser* to other fishes immediately above or below in the animal scale. The results which we employ are, of course, based on external characters only;—they should be further strengthened by careful histological and embryological studies, but let that furnish the subject for another paper.

Two principal varieties of dermal structures we noted in our type. One, in the form of more or less rounded basal plates with spines, approximates very closely to the placoid scale of Selachians. (Fig. 9.) The basal plates in this case are thin and hollowed, and the spines quite long and sharp. In the other case, the basal plates are flat, square, and much thicker, with short and more blunted spines (Figs. 4, 5);—the entire structure very much like the ganoid scales of *Lepidosteus*, the change in outline probably due to specialized conditions, though some (Fig. 5) have preserved an almost unbroken margin.

These are the predominating varieties of derm-denticles, but in addition we must consider two other forms of dermal structure. From what is known of the large body scutes, they can probably be classed with the ganoid type;—the evidence is furnished by fossils, and will be spoken of presently. Figures six and eight present a form somewhat more uncommon than the other derm-denticles. These have hollowed basal plates of a stouter character than the distinctly placoid types, with correspondingly greater spines. Comparing figures six and seven, we can detect certain points of similarity which might lead to the thought that the former are degenerate forms of the latter (Fig. 7, c, d.),—degenerate in so far as they have approached the more primitive Selachian type. One thing that stands in the way is the question of their relative sizes, as one is three or four times the size of the other. If we suppose, however, that separation from its neighbors gave more room for growth, this objection may perhaps be set aside.

A glimpse at a closely related fossil Ganoid will aid in clearing up to a certain extent the relations of all these structures to each other, and also their derivation.

The *Palæoniscidæ* of Palæozoic time have close affinities with our modern Sturgeon. They exhibit similar skeletal features, but were totally covered with scales resembling very much those of the Gar-pike. It is possible to detect slight divergences from the regular arrangement and form of the scales, in lines which approximate closely in position with the scutal rows of the Sturgeon. Bearing this fact in mind, we can assume that a further specialization of these scutes may have taken place, while the intermediate scales were either lost or degenerated. This degeneration can be represented at one stage by the structures shown in Figs. 4, 5. But degeneration also occurred in another direction,—a reversion, an atavism (if we can presume to call it so) to a primitive type from which the *Palæoniscus* itself also probably descended. This reversion we see in such forms as are represented in Fig. 9. The comparison between Figs. 6 and 7 has already been noted, but whether these points of similarity will warrant the belief that Fig. 7 represents a step in the degeneration of the form in Fig. 6, will remain doubtful until further evidence can be brought forward.

The tail region of Fishes in most cases has remained unchanged while other parts of the body may have undergone differentiations in the course of time. If we suppose that *Acipenser* halted at a certain point in its evolution, why not assume that the dermal structures in the tail region had reached the form we recognize to-day, while the other, body scales, had advanced much further. In a certain sense, therefore, they hold a position between the ganoid form and the primitive, Selachian-like prototype,—but of course much nearer the ganoid form.

The other, distinctly placoid scales which were described are probably the result of an independent retrogression. The scales represented in Figs. 4, 5, however, I look upon as directly descended from the ganoid type of *Palæoniscus*. By some means becoming separated one from the other during the evolutions of the Sturgeon, their exact form of growth was not interfered with, which may account for the irregular outline of many, but other characters are like those of a typical ganoid scale.

In conclusion, we may look upon the Sturgeon, as already stated, as having been suddenly halted in its evolution. Its ancestors, the *Palæoniscidæ* and others, point to a more fully armored form, with scales closely related to those of the Gar-pike. But the halt in its evolution also induced a retrogression in one direction and a specialization in another:—many of the ganoid scales disappeared, while some remained in a simpler form, and others were specialized into the five rows of body scutes. The hereditary tendency to assume the characters of a prototype is also well shown in the appearance of distinct Selachian scales.

Nature is ever ready to compromise. In another instance we found a form, *Amia calva*, to mark the transition from Ganoid to Teleost, and here we have a type, with common characters, which can be placed in the scale of Vertebrate life, between Selachians and the other Ganoids.

SOME REMARKS ON CLARIFICATION, AND ALSO ON A NEW CLARIFIER FOR MICROSCOPICAL PURPOSES.*

BY EDWIN A. SCHULTZE.

(*Read October 19th, 1894.*)

One of the most important points to be observed in microscopical research is the requisite clarification of the object under examination. As simple, however, as this appears, the views of the different authorities who have investigated the subject do not appear to coincide. In studying plant sections clarification, according to Dippel, is resorted to to produce the necessary transparency of the object, which on account of its contents does not permit of a thorough investigation of the inner structure. The usual clarifiers mentioned by Dippel are: Liquor potassæ (in some cases to be used with acetic acid and ammonia); potassic alcohol, carbolic acid (when necessary to be used after treatment with alcohol or mixed with turpentine), and finally chloral hydrate (8 parts dissolved in 5 of water). Zimmermann, in his work "Botanische Mikrotechnik," discriminates between the action of the above named chemical clarifiers and the clarification by means of more or less refractive mounting media, especially essential oils, balsams and resins. Of these latter he mentions Canada balsam, dammar and Venetian turpentine. Tschirch, in his "Pflanzen anatomie," speaks of employing only liquor potassæ and potassium chloride, with acetic acid for clarifying plant sections.

Moeller, to conclude, very correctly places water at the head of his list of clarifying reagents; then follow glycerine, alkaline solutions, Javelle water, and finally chloral hydrate. There appears to be a difference of opinion among the authorities on this last mentioned clarifier, which Schimper frequently and highly recommends. Behrens, in his extensive catalogue of clarifiers, calls attention to chloral hydrate "as being only useful for animal preparations" without naming his authority. Moeller mentions chloral hydrate (5 parts in 2 of water) as having been recommended by A. Meyer, and refers to a publication of this last named authority in the "Archiv der Pharmacie," but in which chloral hydrate does not appear. Moeller says, furthermore, that chloral hydrate is preferable to diluted liquids, inasmuch as it leaves the fecula unchanged.

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* Translation from the German of Dr. Wilhelm Lenz. Zeitschr. f. wiss. Mikr. xi. 16 (1894).

Such is, however, not the case, for it is easy to demonstrate that chloral hydrate causes every kind of starch to swell and change into a pasty substance after about 24 hours' time. The formation of this transparent paste does not in any manner interfere with the admirable clarifying properties of chloral hydrate.

I have used chloral hydrate (8 parts dissolved in 5 of water) to a great extent myself as a clarifier for plant sections, and have also recommended its use to those students interested in microscopy at the Fresenius College in this city, and believe I have thoroughly investigated its advantages and disadvantages while comparing it with other clarifiers. A short communication may, therefore, be acceptable on this as well as on a similar clarifier lately discovered by me, and which, I think, is somewhat superior to chloral hydrate.

As already stated, Dippel has explained in a masterly manner the reason for clarifying plant sections. The means for obtaining this result are, 1, the removal of troublesome substances, and 2, the saturation of the object under examination with a body, the refractive power of which is so nearly equal to that of the cell walls, that the light may penetrate as much as possible; but still sufficiently different to admit of the cell walls appearing sharply outlined under the microscope. The division of clarifiers into chemical and physical by Zimmermann, seems to have originated in the above, yet I cannot agree with him for the reason that most of the clarifying solutions act chemically as well as physically, in consequence of which they must be carefully examined and used accordingly. This is especially the case with chloral hydrate. Its excellent double action, chemical and physical, and consequently the ease with which it may be used, has rendered it a very desirable clarifier.

It is remarkable that as yet so little is known of the physical properties and refractive power of the chloral hydrate solution. According to my researches a solution of 8 parts c. p. crystallized chloral hydrate in 5 parts of water has a specific gravity of 1.3677 at 15° C. The refraction of sodium light is 1.4272, and the divergence 0.0078. I have not been able to discover the refraction of pure cellulose.

If we consider, however, that pure cellulose is clarified almost to invisibility in Canada balsam, while remaining clearly perceptible in glycerine of less and styrax of greater refractive power, we may conclude that the refraction of cellulose is about that of Canada balsam. The mean refraction of the latter is said by Behrens to be 1.535.

There are a few drawbacks which must be mentioned in using chloral hydrate as a clarifier. While the action of the alkaline solutions may be nullified with acetic acid, and any turbidity removed with ammonia, this is not the case with chloral hydrate. Fecula and almost the entire contents of the cells are more or less dissolved by chloral hydrate and rendered transparent. In treating these clarified objects with water or glycerine they become turbid.

These defects are far less perceptible in a solution that I have been using for the past six months, and which is composed of equal parts of sodium salicylate and water. This solution has a specific gravity of 1.2315 at a temperature of 17° C. Refractive power 1.4497 and divergence 0.01318 at 15.4° C. According to my former observations the refractive power of the chloral hydrate solution would equal that of a 67 per cent. solution of glycerine. The salycilate solution, as I shall call my new liquid, shows a refraction equal to that of a solution of 82 per cent. of anhydrous glycerine. The penetrating power of my solution is greater than that of chloral hydrate on account of its low specific gravity. Its refractive power is superior to that of chloral hydrate without, however, approaching too closely that of cellulose. It is, therefore, for both reasons, more serviceable as a clarifier than chloral hydrate.

As far as its chemical clarification is concerned the action in swelling the fecula is very prompt. No starch grains were perceptible in sections of ginger after they had lain in the solution about two hours. The coloring of the cell walls is also less changed by salycilate than chloral hydrate.

The latter also gradually causes the cell walls to swell, and, in the case of soft structures, they are sometimes rendered partially imperceptible.

In using salicylate I have not discovered this defect; it appears, on the contrary, to have a hardening effect on soft tissues.

If, as an instance, several thick sections of ginger-root, after having lain about 24 hours in salicylate, and the superfluous liquid carefully removed with filter paper, be mounted in glycerine and examined, the cell walls will be found to be but little swollen, and their color, especially that of the cork cells, well preserved.

All the thin strata appear sharply outlined.

In balsam mounts the details become even more clear and beautiful.

In objects which have been treated with chloral hydrate the cell walls will be found more swollen, their color fainter, their outlines less clearly defined, and the structural details, although in general discernible, somewhat obliterated.

Chloral hydrate is, consequently, only serviceable in examining thick objects, and when these are to be decolored as much as possible. Dyes containing tannin are more influenced by chloral hydrate than by salycilate. The best way to eliminate them is by means of alkaline solutions and afterwards, when necessary, with Javelle water.

Fecula, when swollen in chloral hydrate, forms a transparent jelly, which becomes considerably turbid when a small quantity of water or glycerine is added; a turbidity which increases and forms a thick deposit if this supply is increased.

The jelly produced by fecula swollen in salicylate is much more transparent, does not become cloudy through the addition of concentrated glycerine, and remains, when treated with water, moderately translucent. The swelled fecula reacts with iodine in both cases, but producing two different colors, viz.: the chloral hydrate a red, and the salicylate a pure blue. Salicylate with iodine would, for this reason, be valuable for discovering traces of starch.

Salicylate in general has the advantage of containing a neutral, non-corrosive, non-poisonous and non-hygroscopic salt, its principal chemical virtue being an extraordinary power for swelling starches. The chief feature, however, which renders salicylate so admirably useful in microscopy, is its miscibility with phenols, notably oil of cloves. If one drop of oil of cloves be mixed with 10 of salicylate an opalescent liquid will be obtained, which becomes clear by adding a second drop of oil of cloves. If this process of adding oil of cloves be continued, about the 20th drop will produce a cloudy solution, which may be clarified by a single drop of salicylate. A liquid may thus be obtained with a refractive index of 1.5, which is about that of cellulose.

OXIDE OF ZINC ACCIDENTALLY CRYSTALLIZED.

BY FREDERICK KATO.

(*Read November 2nd, 1894.*)

The crystallized forms exhibited are accidental in so far as there was no intention to produce the substance. It has been found at various zinc and iron furnaces, and in roast and slag heaps in both Europe and America, and it is usually described as "Artificial Crystals of Zincite." Numerous references to occurrences and the literature pertaining thereto are given in Dana's "New System of Mineralogy" (1892), p. 208. This artificial product is crystallographically of interest, because the crystals composing it are, usually, symmetrical and sharp angled; whereas the crystals of the native oxide of zinc, or zincite, are not only extremely rare, but seldom as sharply defined and perfect.

The conditions under which the crystals shown were produced are as follows: in a certain trade requiring the casting of metallic zinc, commercially known as spelter, the metal is fused in graphite crucibles. The bottoms of these gradually burn and wear off, until some time, when a crack or hole is produced in the thinned wall, the fused metal they contain leaks out in drops or a small stream into the surrounding coal fire. The metallic zinc, coming into contact with the glowing coals, ignites and burns with a green flame, forming an oxide, known as zinc white. This zinc oxide vapor, in passing through the coals on its way to the chimney, finds suitable conditions for deposition and crystallization, and it is found attached to the cinders, cementing these together in lumps, and also attached to the crucible.

The deposit varies much in color and character. Sometimes it is chalky in texture and with a mammillary surface, but often it is variously crystallized, as shown. Its color is most usually pure white, though light green and wine yellow are common. The crystals are sometimes transparent. They are sometimes short and stout, or slender and capillary, or again grouped in radiating balls, bristling with fine points. They are generally hexagonal prisms terminated by hexagonal pyramids, or quartzoids, that is they very much resemble quartz crystals in form.

For comparison, artificial crystals of zinc oxide, from the slag heaps of the Passaic Zinc Company, of Jersey City, N. J., are shown, these being much larger, different in habit, and with a beautiful iridescent surface.

PROCEEDINGS.

MEETING OF OCTOBER 5TH, 1894.

The Vice-President, Dr. E. G. Love, in the chair.

Thirty persons present.

Mr. J. D. Hyatt addressed the Society on "Some peculiarities in the Structure of *Cicada septendecim*, the seventeen-year Cicada." This address was illustrated by black-board drawings, and by mounted objects as noted below.

Dr. E. G. Love addressed the Society on the habits and structure of *Cicada septendecim*, and his address was illustrated by prepared slides, photomicrographs and specimens as noted below.

OBJECTS EXHIBITED.

1. Madroporic body of Star-fish: by G. W. KOSMAK.
2. Embryo of *Cicada septendecim.*
3. Larva of the same just emerged.
4. Stridulating apparatus of the male of the same.
5. Photomicrographs; embryo and young larva of *C. septendecim.*
6. Specimens; imago of *C. septendecim* ♂ and ♀, imago of *C. tredecim* ♂ and ♀, imago of *C. pruinosa* ♂ and ♀, larva and stridulating apparatus of *C. septendecim*, spores of the fungus, *Massospora cicadina* Peck, from the abdomen of the same, and the Digger Wasp, *Sphecius speciosus.*

7. Photomicrographs of sections of tabular quartz from Thomaston, Ga., and of conglomerate from Brooklyn, N. Y. Exhibits Nos. 2–7, all by E. G. LOVE.

8. Larva of *Cicada septendecim*: by J. D. HYATT.

9. Mouth-parts of the same: by J. D. HYATT.

10. Ovipositor of the same: by J. D. HYATT.

11. Anterior leg of larva of the same: by J. D. HYATT.

12. Specimen of *Vespa crabro* L.: by J. D. HYATT.

13. Specimens of the "Snow Flea": by J. D. HYATT.

MEETING OF OCTOBER 19TH, 1894.

The President, Mr. Charles S. Shultz, in the chair.

Thirty-four persons present.

Mr. E. A. Schultze read a paper, entitled "Some remarks on clarification, and also on a new clarifier for microscopical purposes." This paper was a translation from the German of Dr. Wilhelm Lenz, and is published in this number of the JOURNAL, p. 22.

OBJECTS EXHIBITED.

1. Resolution of *Amphipleura pellucida*, mounted in realgar (artificial): by HENRY C. BENNETT.

2. Antenna and anterior leg with antenna cleaner of the male Leopard Moth, *Zeuzera æsculi* L.: by J. L. ZABRISKIE.

3–8. Hymenopterous parasites of lepidopterous eggs; *Cosmocoma euchariformis*, *Eustochus atripennis*, *Alaptus minimus*, *Camptoptera papaveris*, *Gonatocerus flavus*, *Anagrus incarnatus*: by E. G. LOVE.

9. Twelve photomicrographs displaying both the ♂ and ♀ of the above parasites: by E. G. LOVE.

10. Oolitic sand from Great Salt Lake, Utah: by F. D. SKEEL.

11. Foraminiferous sand from Newport, R. I.: by F. D. SKEEL.

12. Whale-louse from head of whale: by F. D. SKEEL.

13. Segmented eggs of Sea-urchin, *Toxopneustes*. Various stages, from two-celled to blastula stage, the latter also shown in section: by G. W. KOSMAK.

14. One and one-half inch home-made eye piece: by ALFRED KROGER.

Mr. Bennett described the artificial production of the medium in which his exhibit was mounted: 1 part of sulphur to 1.7 parts of arsenious acid, the realgar being condensed on the cover glass and then fused on the slide.

Mr. Zabriskie stated concerning his exhibits:

The European Leopard Moth, the larva of which was observed in Central Park, New York City, by Dr. E. B. Southwick, in 1884, became established in this region about the year 1887. It is said to be more abundant and more destructive to shade trees in the City of Brooklyn and the immediate vicinity than it is at present in any particular locality in Europe. Col. Nicolas Pike observed it in Brooklyn in 1888, and found it widely spread over the region in 1892. The eggs, laid in groups with a fluffy covering, hatch early in June. The young larvæ cluster for some hours, and then separate for their destructive work, frequently boring in the trunks of trees, ultimately leaving a burrow nearly half an inch in diameter, and consequent large patches of dead bark and dead wood, but more frequently entering at the junction of two limbs of trees, being the most usual cause of the abundant broken limbs strewed upon the ground or pendant in the trees, as seen here after a storm. Col. Pike lists twenty-four species of trees as ravaged by this moth in Brooklyn, and Dr. E. B. Southwick lists twelve species attacked in Central Park, New York City. The remedies proposed are arsenical sprays, and injection of carbon bisulphide into the burrow followed by stopping with putty (Southwick).

The male antenna is broadly pectinate for full one-half its length from the base. A stout prong extends horizontally from either side of each pectinated joint, and each prong is well furnished with white bristles also extending horizontally. The antenna cleaner is found in both sexes, but is largest in the male. In this case it is an unusually large movable spine, attached at the basal end of the anterior tibia, closely applied to and nearly as long as the tibia itself.

Dr. Love explained that the hymenopterous parasites exhibited by him were prepared by the late Mr. Frederick Enock. They are beautifully mounted in balsam, with wings and legs extended, and the largest specimen measures scarcely one-twentieth of an inch in length.

Dr. Skeel said that his oolitic sand was found in quantities on the shores of Great Salt Lake, and that the grains show a remarkable similarity in size and form, being all ovoid. And further that the whale-louse was one of a great number found in a hole in the head of a whale, the tarsal claws enabling the creatures, when living, to clasp a needle or a bristle with great tenacity.

MEETING OF NOVEMBER 2D, 1894.

The President, Mr. Charles S. Shultz, in the chair.

Thirty-two persons present.

A communication from Dr. Arthur Mead Edwards, of Newark, N. J., was read, entitled "Microscopical examination of dust which fell off the coast of Africa."

OBJECTS EXHIBITED.

1. A new formula, 1-12 inch homogeneous immersion objective of E. Leitz: by CHARLES S. SHULTZ.
2. Eye-piece micrometer of exceedingly fine platinum wire of E. Leitz: by CHARLES S. SHULTZ.
3. Transverse section of stem of *Nuphar luteum*, polarized: by THOS. S. NEDHAM.
4. Oxide of zinc, crystallized, an accidental furnace product: by FREDERICK KATO.
5. Section of cork compared with Chinese rice paper: by F. W. LEGGETT.
6. Section of opalized wood with precious opal from Australia: by JAMES WALKER.
7. *Plumatella*, living, by A. D. BALEN.
8. An old home-made microscope: by A. D. BALEN.
9. Scales of *Lepisma saccharina* under a 1-inch objective: by T. B. BRIGGS.
10. Preparations of the metamorphoses of the edible frog, *Rana esculenta*, in alcohol: by HENRY C. BENNETT.

President Schultz gave an account of his late visit to the manufactory of Mr. E. Leitz, Wetzlar, Germany, a large establishment entirely devoted to the manufacture of microscopes and their accessories, everything being conducted on the most systematic plan. He was especially interested in the production of objectives on a new formula, of finest workmanship, of moderate price and having interchangeable parts. Parts of these objectives were mingled together in his presence and then reassembled with entire satisfaction.

Mr. Kato donated specimens of his crystallized oxide of zinc for distribution among the members.

Mr. Henry C. Bennett explained his preparations of the frog: "This is an exhibition of the metamorphoses of the Edible Frog, *Rana esculenta*, preserved in alcohol, and prepared by W. Haferlandt of Berlin. The specimens are all fastened in order on the surface of a milky glass plate, 3 by 14 inches in dimensions, which is immeresd in alcohol, contained in a tall rectangular glass jar measuring internally 2 by 3½ by 14 inches. The five small test tubes containing eggs and larvæ are held to the glass by a very thin thread, and the tadpoles and frogs are also secured to the plate by threads so passed through the skin as to be scarcely observable. The specimens in succession are as follows: 1, the round eggs; 2, the eggs elongated; 3, larva with head, tail and branchiæ distinguishable; 4–6, the same, showing successive stages of diminishing branchiæ, with body and head much altered, and with gill covers appearing; 7, 8, the same, showing the progression of the posterior legs; 9, the same, with the anterior legs appearing; 10, the same more fully developed; 11, the young frog with the tail nearly absorbed; 12, 13, fully developed frogs."

MEETING OF NOVEMBER 16TH, 1894.

The President, Mr. Charles S. Shultz, in the chair.

Twenty-seven persons present.

Dr. T. O. Summers and Mr. A. J. C. Anderson were elected resident members of the Society.

The following persons were appointed by the chair as Committee on Annual Exhibition: George William Kosmak, Thomas B. Briggs, George H. Blake.

OBJECTS EXHIBITED.

1. Segmented eggs of *Amphioxus lanceolatus*, 4-cell stage: by G. W. Kosmak.

2. The same, 8-cell stage: by G. W. Kosmak.

3. The same, 32-cell stage: by G. W. Kosmak.

4. The same, gastrula stage: by G. W. Kosmak.

5. Section of nepheline dolerite: by Charles S. Shultz.

6. Section of blast-furnace slag, Sheffield, England: by Charles S. Shultz.

7. Section of pikrite, Scotland: by Charles S. Shultz.

8. Parts of embryo cat, preserved in formaldehyd: by L. Riederer.

9. Embryos of the southern lizard, *Anolis*, preserved in formaldehyd: by L. Riederer.

Mr. Kosmak illustrated his exhibits by the use of blackboard drawings; stated that the eggs were brought from the Straits of Messina by Prof. Wilson, and that Prof. Whitman and Johns Hopkins University had some of the same, there probably being no others in this country; explained the segmentation and the peculiarities of the structure; and gave some notice of the observers of the development.

Mr. Riederer spoke of the excellent preservative properties of formaldehyd for anatomical specimens, and explained that the embryos of *Anolis* were reared by himself.

Mr. Kosmak remarked that these embryos were rare and interesting; referred to the puncturing of the egg shell by the chick, and the presence of the premaxillary tooth in the snake and the alligator, drawing a line and aiding in the splitting of the shell; and stated that it would be a great satisfaction to know if this tooth exists in the case of *Anolis*.

Meeting of December 7th, 1894.

The President, Mr. Charles S. Shultz, in the chair.

Fifty persons present.

Mr. Reginald C. Woodcock was elected a resident member of the Society.

The following persons were appointed by the chair as Committee on Nominations of Officers: F. W. Devoe, William G. De Witt, Walter H. Mead, William E. Damon, F. W. Leggett.

Dr. T. O. Summers read a paper, entitled "Pronuclein, the Phagocytoblast of the Organism." This paper was illustrated by microscopical mounts as noted below, and was discussed by Prof. Schweitzer, Dr. Seld and Mr. Kato. The thanks of the Society were tendered Dr. Summers for the presentation of this paper.

OBJECTS EXHIBITED.

1. Pure nuclein.
2. The same acted on by the blood.
3. The same prepared in sugar.
4. The same mixed with blood corpuscles.

Exhibits Nos. 1–4, by T. O. SUMMERS.

5. Hydroid, *Eudendrium*: by G. W. KOSMAK.
6. Hydroid, *Pennaria*: by G. W. KOSMAK.

Mr. Kosmak explained his exhibits, referring especially to the digestive functions of *Hydra*.

MEETING OF DECEMBER 21ST, 1894.

The President, Mr. Charles S. Shultz, in the chair.

Twenty-nine persons present.

Dr. Henry S. Hathaway and Dr. H. A. Parmentier were elected resident members of the Society.

Mr. Walter H. Mead reported for the Committee on Revision of the By-laws, proposing certain amendments.

On motion the report was accepted and adopted, and the Committee was discharged.

Mr. Mead also reported for the Committee on Nominations of Officers the following nominations for the year 1895: President, Edw. G. Love; Vice-President, Frank D. Skeel; Recording Secretary, George E. Ashby; Corresponding Secretary, J. L. Zabriskie; Treasurer, James Walker; Librarian,

L. Riederer; Curator, George E. Ashby; Auditors, F. W. Devoe, F. W. Leggett, E. A. Schultze.

The Corresponding Secretary read a communication from Mr. K. M. Cunningham, of Mobile, Alabama, describing a new diatom. This communication was accompanied by a donation to the cabinet of the Society of a specimen of the radiolarian chalk, and a prepared slide and drawing of the diatom, to all of which reference was made.

OBJECTS EXHIBITED.

1. *Alcyonium palmatum*, mounted entire: by G. W. KOSMAK.
2. The same, transverse and longitudinal sections: by G. W. KOSMAK.
3. *Branchippus stagnalis*, living: by A. D. BALEN.
4. Photomicrograph of a leak in a glycerine mount: by E. G. LOVE.

Mr. Balen remarked that *Branchippus* appears late in the Fall, being found in water coated with ice, under which conditions it will flourish until Spring and then disappear. He had never found it later in the Spring than the month of March. The eggs fall to the bottom of the water, where they remain during the Summer. Like the eggs of *Hydra* they are well furnished with spines.

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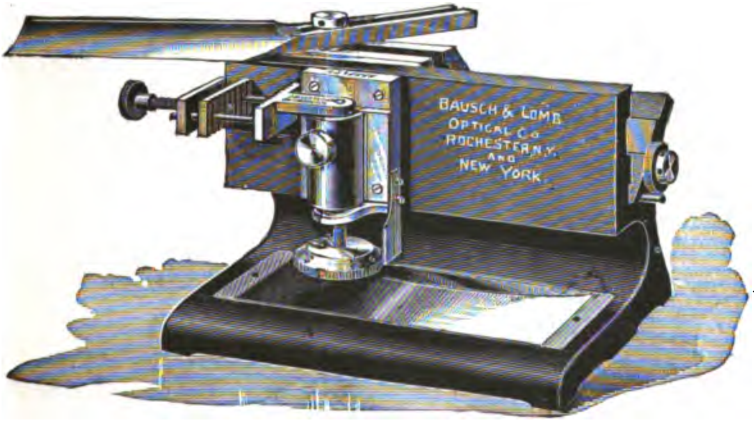

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Vol. XI. JULY, 1895. No. 3.

10,412

JOURNAL

OF THE

New-York Microscopical Society

EDITED BY

REV. J. L. ZABRISKIE,

28 REGENT PLACE, FLATBUSH STATION, BROOKLYN, N. Y.

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INC. 1877

New-York:
PUBLISHED FOR THE SOCIETY,
QUARTERLY.

PRESS OF DOUGLAS TAYLOR & CO.
NO. 8 WARREN STREET.
1895.

[Entered at the Post-Office at New-York as second-class matter.]

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JOURNAL

—OF THE—

NEW-YORK MICROSCOPICAL SOCIETY

CONTAINING ITS TRANSACTIONS AND PROCEEDINGS.

PUBLISHED QUARTERLY.

All communications for the JOURNAL, all subscriptions, and all exchanges, should be addressed to the editor, Rev. J. L. Zabriskie, 28 Regent Place, Flatbush Station, Brooklyn, N. Y.

Terms of Subscription:—In the United States, Canada and Mexico, One Dollar per annum, beginning with the January number. In other countries, One Dollar and Twenty-five Cents per annum.

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JOURNAL

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NEW-YORK MICROSCOPICAL SOCIETY.

VOL. XI. OCTOBER, 1895. No. 4.

MICROMETRY.

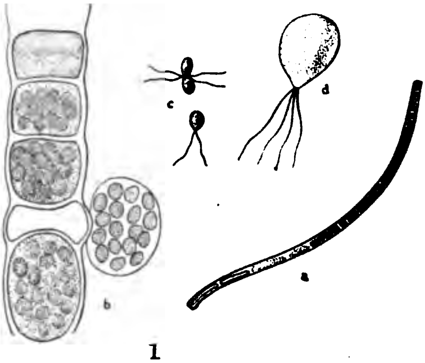
BY E. G. LOVE.

(*Substance of some remarks made before the New-York Microscopical Society.*)

Whoever undertakes any serious work with the microscope is confronted sooner or later with the necessity for some method of determining the actual size of microscopic objects; and it may not be without profit if we briefly review the different methods for ascertaining this.

As we might naturally suppose, the earliest efforts in micrometry consisted in comparing the miscroscopic object with other objects whose approximate size was known or could easily be determined. Thus Leeuwenhoek employed grains of sea-sand of such size that 100 of them, placed side by side, extended one inch. One of the sand grains was so placed that it could be directly compared with the object under the microscope. The same idea was adopted by later microscopists who employed the very small spores of certain plants.

Hooke, as early as 1675, described a method for determining the magnifying power of a microscope. To use his own words:—"Having rectified the Microscope, to see the desired Object through it very distinctly; at the same time that I look upon the Object through the Glass with one Eye, I look upon other Objects at the same Distance with my other bare Eye: by which means I am able, by the Help of a Ruler divided into Inches and small Parts, and laid on the Pedestal of the Microscope, to cast as it were the magnified Appear-



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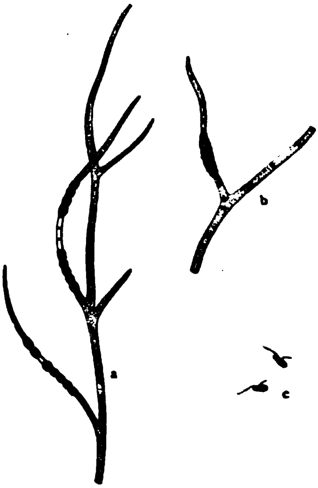

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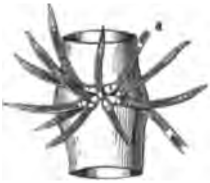

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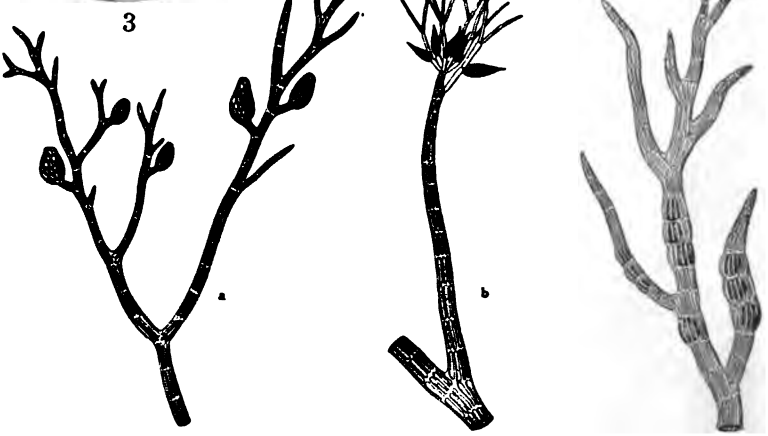

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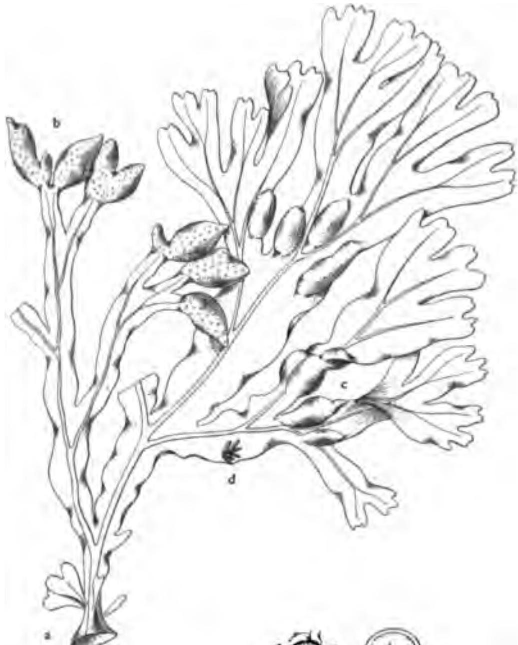
CURTIS ON ALGÆ.



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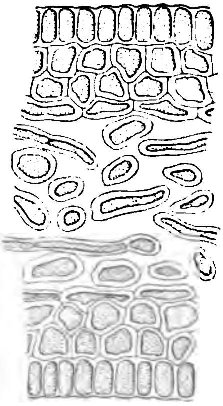

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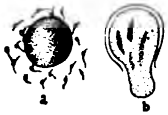

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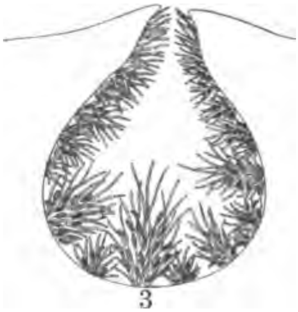

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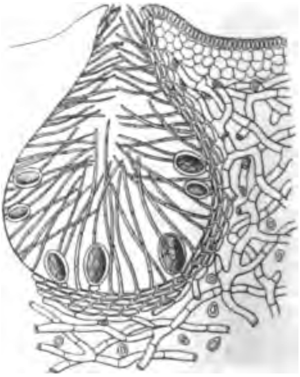

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CURTIS ON ALGÆ.

JOURNAL

OF THE

NEW-YORK MICROSCOPICAL SOCIETY.

VOL. XI. JULY, 1895. No. 8.

SOME INTERESTING FEATURES OF WELL-KNOWN PLANTS OF NEW-YORK HARBOR.

BY CARLTON C. CURTIS, PH.D.

(*Delivered May 17th, 1895.*)

I trust that the discussion of this paper may be of interest to the members of this Society, for especially to the microscopist should the Science of Botany be full of attractions. There is a very prevalent feeling abroad that the study of Botany is of little practical importance compared with other subjects, that the results yielded are not in keeping with those

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Explanation of Plate 50.

FIG. 1.—*a*. *Ulothrix flacca* (Dillw.) Thuret. The basal portion of an old filament. × 45. *b*. A few cells enlarged, showing escape of zoospores. × 190. *c*. Zoospores, showing their development as gametes in the first stages of conjugation. *d*. Zoospore. The early stage in its development has been indicated in the upper cell in *b*. × 190.

FIG. 2.—*a*. *Ectocarpus littoralis* Lyngb. Upper portion of a branching filament. Some of the cells are enlarged by the formation of unilocular sporangia. × 30. *b*. A portion of a filament with a plurilocular sporangium. × 45. *c*. Zoospores.

FIG. 3.—*Calothrix confervicola* Ag. A fasicle of filaments growing on an alga. An escaping hormogonium is figured at *a*. × 40.

FIG. 4.—*a*. *Polysiphonia nigrescens* Grev. Tip of frond, showing young cystocarp. × 20. *b*. Branchlet of the same with antheridia. × 20. *c*. Terminal branch with tetraspores. × 20.

Explanation of Plate 51.

FIG. 1.—*Fucus vesiculosus* L. × ½. *a*. Rhizoidal portion. *b*. Tips of the frond bearing conceptacles. *c*. Air bladders. *d*. Prolifications.

FIG. 2.—Cross section of a small branch. × 190.

FIG. 3.—Median section of a conceptacle with antheridia. × 200.

FIG. 4.—Median section of a conceptacle with oogonia, the oospheres showing in some of the sacs, also the cell structure on the right hand. × 200.

FIG 5.—Fertilization of the oosphere and growth of the oosperm. × 500. *a*. The oosphere surrounded by the antherozoids. *b*. The oosperm germinating after about two hours.

of other fields. In schools it is looked upon as an ornament, in life as an amusement. The *fin-de-siècle* student considers the subject rather as a flourish or ornament to his education, adding something of finish it may be, setting off to better advantage the completed structure. And so he attacks the subject much like a chicken picking at a bone, neither, I fancy, has any serious thought of ever getting the best of the matter under consideration. Naturally then with misconceptions and no real knowledge of the subject, having "finished his education," if he has the temerity to again cultivate the field he invariably enters by the one road where angels would fear to tread, and begins upon a work for which not one man in a thousand has any fitness or possibility of securing any scientific knowledge. He flatters himself that in the interest of science he is counting parts and comparing outlines, but the chances are that the same motives that urge the bug from flower to flower, the caloric advertisements hung out by the plant, are the chief stimuli to his work. In attempting the problems of taxology he enters upon the most difficult field in Biological Science. One requiring not only the broadest education but natural gifts and powers that are not within the bestowal of any educator or institution. So he is fated not only to work to no purpose, but to do poor work which will be an injury to others and worthless to himself, if we except that which must accrue to his benefit from the exercise in the field. The great evil of all these conditions is that such men are looked upon as Botanists. This is all the meaning that attaches to the subject. To how many does the name signify anything more than plant analysis?

Then again we are a restless, eager people, fond of movement and things that move. The quiet subtile life, abundant and on every hand, does not appeal to us; and especially is the painstaking plodding study of it distasteful. Our scholastic character is fairly well reflected in the admonitions of the annoyed judge—he wanted silence in the court and mighty little of that. It is a matter for encouragement, however, that the importance of this side of Biology is being recognized in this country. Already some work is finding its place among the studies of a few institutions and matters are shaping themselves to give it a recognition worthy of its importance. The writer was forcibly reminded of this some time since in speaking with the head of the biological department of an institution of which we are all justly proud. After speaking in the most orthodox manner of the relationship of the two branches of his chair and showing with pardonable pride the work in Zoology, being called upon to outline the work in Botany, he remarked that owing to the financial depression, etc., it had been impossible to establish a course in Botany on a scale at all commensurate with the dignity of the subject. He was reduced, perhaps wickedly, to the humility of confessing that the work was confined to a single term and was of an order comparable with that of a good high school. The boys heard lectures on stem, root and leaf, the formation of the seed and its germination—"the cycle of life, you know." It occurs to the writer that it is rather unjust to attribute the neglect of Botany to the financial measures of political parties.

This evening a few plants, not only the most common but also the most offensive to sight in your harbor, have been selected for discussion with the hope that the paper might gain something of advantage by contrast, and more especially that my audience might be driven by the consideration of a dry paper to seek relief in the study of one of the most interesting provinces of Botany. Perhaps no field presents more interesting problems in phylogeny, certainly none shows so clearly the forces at work under the simpler conditions of life here imposed; and truly all those questions of relationship, habitat and range, of structure and life processes lose nothing of interest among these lowly forms. Although characterized by wide morphological differences and variations in life histories, nevertheless it will be found that the simplest are wonderfully constant in their development. Much has been said concerning the polymorphism of these simple forms, and superficial observation has given much wider currency to this belief than the facts will justify. It is a common occurrence to note in apparently pure cultures the replacement of one form by another. It should be borne in mind that evidence of this kind is of little value, for it is more than probable that spores of many forms have been gathered, and the changed environment was the condition necessary to bring into life one form or destroy another.

In this connection is of interest the recently published observations of Alexander Artari on the Protococcoideæ. In a series of observations of long duration he has observed under the microscope the growth of these minute plants. Being first sure of the purity of his cultures he subjected the plants to all changes possible, such as variations of light, heat, food, atmospheric conditions, and following them through their life histories established beyond doubt, it would seem, the constancy of sixteen species of the order, many of which have been considered very doubtful. These observations are especially noteworthy because the studies were made on unicellular plants that are probably archaic forms and especially liable to variation.

A common member of the summer flora of the harbor is found on the larger algæ or in patches on the rocks giving a dark bluish green color to the substratum. The fasiculate tufts, the filaments terminating in a hyaline hair, and provided at their bases with one or more conspicuous cells, heterocysts, render easy the recognition of this microscopic plant. The *Calothrix* belongs to one of the simplest groups of plants. In morphological characters and life processes it often closely resembles the bacteria. The cysts of the filaments can hardly be spoken of as cells, for they contain neither a nucleus in the common acceptance of the word, nor chlorophyll; while the mucilaginous character of the cell wall renders difficult its sharp separation from cell contents. The lowly condition of the plant is indicated by the general diffusion of the chromatic substance through the cytoplasm, and by the absence of chlorophyll and consequently of starch, also by the distribution of the nuclear substance and the absence of distinct organic substance in wall and cell contents. In fact every feature of the physiology points to a very primitive stage in the evolution of plant life. None the less simple is its growth and propagation. Any of the cells may divide to increase its length. Multiplication of species, so far as observation teaches, is only accomplished by the escape of a few cells of the filaments and, after a period of rest, these grow into a new plant. It is reasonable to expect that propagation is also effected by the rejuvenescence of a single cell and spore formation. In *Calothrix confervicola*, the plant common with us, I have seen no indications of this. There are no sexual processes.

At many places along the beach, where there is shore drainage, or between the tides, will be seen brown slimy patches on the mud and rocks, and scarcely can a plant or stick be removed from the water without giving the same slimy feel and affording myriad examples of another and the most common plants in the harbor, the diatoms. I am not so presumptuous as to offer to a microscopical society any facts on diatoms, but introduce these much observed plants as one factor in the biological series under consideration. Their life history, though simple, presents a decided advance over that of *Calothrix*. Although no plants have received so much study, nevertheless there remains much to be determined concerning the minute structure of the cell. However certain known features of the gross anatomy, such as the nucleus, chromoplasts and starch indicate clearly that we have arrived at a much higher horizon in life. They commonly multiply by vegetative propagation. The two overlapping valves of the frustule draw apart, the cell contents divide, and the two old valves separate entirely to form each a new valve, covering the exposed portion of its cell contents. This new valve fits within the old, so that with each succeeding generation must be associated a reduction in size, for owing to the silicified valves no growth in length can occur. When a minimum size has been attained a return to their original greatness is effected in a variety of ways quite in keeping with their simplicity. The common and probably the *sui generis* method comprises four stages arranged about as follows: the casting off of the valves, growth of the naked cell, secretion of a cellulose coat, and when the maximum growth has been attained the formation of silicious valves within the cellulose wall. Sometimes, as if under the influence of habit, the second stage is varied by a bipartition. A common mode of propagation is very suggestive of conjugation. Two cells arrange themselves side by side, become enveloped in a gelatinous mass, and, with the discharge of their valves, the two naked cells behave in their growth as noted above. In the last and highest form of multiplication of species to be noted we find a reproduction. process. The early stages resemble the previous method, but the life cycle is completed by the mingling of the two naked cells to form a zygosperm. Thus we see that the advance is more pronounced in the processes of propagation and reproduction than in morphological characters. For, although there is an unmistakable tendency among these unicellular plants to become filamentous, on the other hand the diatom rises from purely vegetative and asexual to sexual methods. Sex, however, has not been established. An interesting question here presents itself to the members of the Society—whether we are to consider the third case simply as an asexual propagative method, as in the first and second examples, or have we a case of parthenogenesis? The former seems to me to be the more natural supposition. In the diatoms we are dealing with the lowest members of a natural group, and by gradual changes are to be evolved the more complicated processes.

If one thing stands out clear above another to the botanist, it is this fact that he is dealing with life that is writing over and over for his dull understanding, in varied form to be sure, the same history. Each natural group repeats the tale. This life has pushed out in its ascent along many lines, attaining a higher or lower horizon in each group, according as the plan or method of the particular scheme followed was of advantage or not. Little advantage can come from speculating upon the probable ancestors of a particular form, as compared with a study of its immediate connections. Here is a trend along which life is developing. Not so much importance then the character of the ancestors, for their offspring were sports, and these and their remote surviving descendants are subject to new laws, in fact are proceeding along new lines, and naturally reveal more of truth about themselves than their ancestors.

It is a disputed question, however, whether we have an example of rejuvenescence or apogamy, whether we have an approach to sexual processes, or an illustration of retrogression.

Another plant more conspicuous from its size and nearly as common, covers the wood work and stones between the tidal limits with a grass-green coating. The *Ulothrix* consists of a single chain of cells that possess intercalary growth. These vegetative characters we saw foreshadowed in the bipartition and tendency to form filaments among the diatoms. This form is of interest to us because it illustrates a decided advance in reproductive processes. Any of the cells may increase in size, and by the segregation of the cell contents, small ovate naked bodies are formed that escape through the ruptured wall. These zoospores are rendered mobile by four cilia, and after various journeyings attach themselves by the jointed hyaline end, the root portion, withdraw their cilia, secrete a cell wall, and by subsequent transverse divisions form a new plant. It is of interest to note this early appearance of the root. The basal cell differs little morphologically from the other cells save in its lack of chromatophores. Several adjoining cells usually are changed more or less in character, and all become with age somewhat irregular in form and more or less colorless. This primitive root has only acquired the lesser portion of its functions. It plays no part in the economy of the plant other than that of an anchor. The important function of absorption is yet to be acquired. Similar but smaller and biciliated bodies are also formed in the vegetative cells, and these are of especial interest. They may have a similar life cycle to that just noted, but it is worthy of note that the resulting plant is not so large as the one produced by their larger relatives. However, after emerging from the cells two may conjugate and, after a somewhat complicated series of changes, give rise to a new plant. Although asexual propagation is still common, sexuality has become clearly established. Furthermore, it will be noted that while these gametes are externally similar, still it is not to be doubted that sexual differences exist among them. Strasburger has always maintained that the sexes are equivalent and has attempted to show that in the mingling of the gametes in the plant world there is no extrusion of the polar bodies, emphasizing his statement by his recent magnificent demonstration of the reduction in the number of the chromosomes in the nuclei of the gametophyte, as compared with the number in the nuclei of the sporophyte. It is easily imagined that this is no small solace to one who has always maintained that the so-called sexual characters are simply external adaptations to ensure conjugation, and that now no further argument is necessary to establish the physiological identity of the sexes. For my own part it seems to prove nothing of the kind. We have gained one step in the *modus operandi* of life processes, nothing as to the nature of the process. Why must the conjugating gametes be derived from two cells if the sexes are equivalent physiologically? If conjugation is not effected, why are they unable to form a new plant at once like the larger zoospores, but must needs wait till something apparently has been added to them before a new vegetative growth is possible? However, with conjugation two complimentary bodies have mingled, and now no time need elapse for gaining strength before a new growth will ensue. It should be added that the zygosperm passes through a period of rest, as is usual in all cases of this kind; but first comes a root growth by which it is attached to the substratum. But one reasonable explanation can attach itself to the behavior of these bodies. The smaller ones have suffered some loss that incapacitates them for immediate independent growth. It would appear evident that some had lost certain vital elements, and that others had retained these elements to be deprived in turn of others, and that it is just such distinctions that constitute sex. External form signifies nothing as to the nature of the object, although naturally nature and external characters will be associated. So the mingling of these two bodies, externally similar, brings all the elements necessary to growth, and without this fusion time must elapse sufficient for the building up of the missing factors of growth. In the case of the zoospores, however, the elimination of necessary material has not been suffered, and immediate growth follows.

Another familiar plant forms soft yellowish brown masses, either floating free or attached to water plants. In the *Ectocarpus* we note an advance over other forms in the excesssively branched filaments, but again chiefly in its reproductive characters. While the growth of the filaments is intercalary, it is largely relegated to definite lower portions, and the distribution of labor is more manifest in the setting aside of the cells in the continuity of the branches for reproduction and propagation. Perhaps, however, in the septation and specialization of one of these vegetative cells for the formation of gametes, that behave much like those noted in *Ulothrix*, we find the most significant advance yet noted. And, again, in the conjugation of these similar gametes it has been observed, in some species of the genus, that one retains its mobility longer than the others. In the shorter mobile period of one of the gametes (female) we have the simplest observable differentiation of sex. In some species the sexes are recognized by their size.

Passing now to the rockweed that renders unseemly so many places about the harbor, we first are impressed with the rise in importance of vegetative characters. Externally we have a segmentation into root, stem and leaf, and physiologically this is also true. The root is simply a disk exercising but one of its functions. The thickened rounded portion finds its homologue in the stem of the tree, while above the broadened wings expose, as surely as a leaf, the chlorophyll pigments to the light. In the anatomy of the plant we note considerable differentiation of tissue and corresponding distribution of labor. A clearly marked epidermal zone with prolonged growth thus filling the place taken by the phellogenetic meristem. Beneath this rind the cells produce lateral outgrowths, ramify the central portions of the stem, and suggest a cambium zone, an analogy not so remote when we consider some of the larger allies, and finally in the centre extend the elongated cells of the medulla, the forerunners of the basal strings. With this outline in the phytotomy of the *Fucus* let us pass to the reproductive parts. These are located in cavities at the tips of the branches and mark the consummation of reproductive processes in this line of ascent. Asexual propagation has been entirely replaced by the sexual. Definite portions of the plant are now devoted to the formation and protection of the highly specialized organs. The species under consideration is diœcious, securing the advantages of cross fertilization, and the sexes are clearly marked. The female cell, oosphere, has lost the power of motion, as was hinted at in *Ectocarpus*, while the male, antherozoid, remains mobile. With the escape of these bodies from the mother cell the oospheres will soon be seen to slowly rotate owing to the large number of antherozoids that become attached to them. After about an hour one of the gametes has mingled with the oosphere, when a cell wall is formed and, without a period of rest, the oosphere begins to develop a new plant.

There remains but one step in advance to complete the plan of growth resorted to in the plant world. Along the coast at low tide will be found a good illustration of this stage. The *Polysiphoniæ*, though not presenting such gross vegetative characters as the *Fucus*, in their growth, ramifications, and cortications, are as highly differentiated, while in reproductive characters, though belonging to the "submerged tenth," nevertheless afford a glorious prophecy of the plans that are to be resorted to among their more exalted relatives, though two grand epochs must intervene to see them fully worked out and realized in the flowering plants. To cut short this too long paper, only a few points in reproduction will be noted. We have at last arrived at a point, indicated almost in the beginning, where the propagative and reproductive parts are no longer mobile but dependent upon the currents in the water for propagation, as are the Phonerogams upon the wind, and, as in the seed plants, so here the female cell never leaves the gametophyte. In fact, we cannot speak of a female gamete. The cell that receives the stimulus of the male cell is an undifferentiated cell. The contents of the male cell is transmitted through an apparatus strongly suggestive of stigma, style and ovary, but by a process quite unique in biological science propagative bodies are formed. We can neither speak of the process as conjugation or fertilization. There is no fusion of equivalent gametes or impregnation of an oosphere, and of course no zygosperm or oosperm results. The receptive, undifferentiated cell seems simply, to be quickened into vegetative life, a process that usually attends pollination among vascular plants. After a considerable growth spores arise in some of the ultimate cells, and the whole growth becomes inclosed by a cortication that springs from the lower surrounding cells.

The reader will, of course, understand that no natural sequence has been attempted, but rather a few of the salient points of our most common and unattractive plants have been touched upon, to illustrate the facts that are easily within the range of any observer.

I am indebted to Mr. F. Emil for the illustrations.

THE RELATION OF APERTURE TO THE DETERMINATION OF MINUTE STRUCTURE.

BY CHARLES F. COX.

(*Abstract of a Paper read February 15th, 1895.*)

The central idea of Prof. Abbe's theory of microscopical vision is that, for the eye to perceive a true image of an object, all light rays from that object must be gathered up and transmitted by the objective and recombined at its back. He formerly held that there was an essential difference between refracted and diffracted rays, and that there were two distinct images formed by them. But he has more lately reached the conclusion that there is no difference in principle between the rays, and that, as a matter of fact, there is but one image-forming process, which is diffractive. The rays upon leaving an object are supposed to be dispersed at all angles from the direct axial line up to the maximum of 90°, so that, to receive and completely combine them, we require a lens of 180° aperture in the medium which surrounds the object. Every object, however, is composed of large parts and small parts, and it is a deduction from the theory that the angle of diffraction for any ray is in inverse proportion to the size of the element or detail of structure from which it emanates, so that for a coarse structure the dispersion will be confined to a relatively slender cone of light, which may therefore be taken up and recombined by a correspondingly narrow-angled objective. The lens will in such case produce a truthful image. But the dispersion becomes greater with finer details of structure, and in order to admit the rays from them the aperture of the objective must be proportionally widened.

Owing to the complexity of the modern objective available aperture is much less than the theoretical. The measure of the former is, in practice, "the ratio between the utilized diameter of the back lens and the focal length of the objective," that is to say, the proportion of back lens which can be filled with image-forming light. Assuming that the total area of the back lens is in accordance with calculation for the combination to which it belongs, the available area, in the case of an apochromatic, is generally conceded to be about seventy-five per cent. Consequently, although objectives are made with the full theoretical aperture of 180° in air, and of something more than 161° in oil, none of them is capable of projecting from its back lens anything like the whole of the rays which leave the object and which appear to be taken in by the front lens, and so all our finest optical combinations must inevitably, according to the diffraction theory, fall far short, not only of an ideal performance, but even of their calculated efficiency. Accordingly, Prof. Abbe has propounded the doctrine that no known method of construction can produce an objective capable of giving a true image of any structure composed of parts which are closer to one another than within the $\frac{1}{2500}$ of an inch, and, as an example, it is declared that "our finest homogeneous objectives of greatest aperture invariably fail to reveal to us the real structure of the finer kinds of diatom valves."

It is a further deduction from the diffraction theory that an oblique illuminating pencil, by throwing a part of the base of the inverted cone of light from the condenser beyond the angular grasp of the objective, must be fatal to a correct image, particularly with a condenser having a practicable aperture equal or close to that of the objective. It is therefore the teaching of Prof. Abbe and his followers that "strictly similar images cannot be expected except with *central* illumination with a narrow incident pencil, because this is the necessary condition for the possible admission of the whole of the diffracted light."

The facts just stated raise two important questions: (1) Why should we continue the use of high power objectives in biological and morphological investigations, after being told that in the very nature of things they cannot give anything but false answers to our inquiries; and (2) why should we spend our money upon, and perplex ourselves with, wide-angled sub-stage condensers, since the highest authorities have declared that they only add to the perversions and misrepresentations of the objectives?

As to the first question, it is quite evident that we do not believe the statement upon which it is founded. This is plainly one of the cases in which we go on repeating the orthodox creed while qualifying it by some secret mental reservation. But if our apochromatics cannot possibly tell the truth as to minute structures, are we not bound to discard them in our investigations of such structures? Or, if we persist in their use and continue to believe in their revelations, should we not give some consistent and reasonable explanation of our adherence, at the same time, to the so-called diffraction theory of vision? My object is not so much to state my own position, which is of little importance, as to reopen the general question for debate. I am free to say, however, that I am one of the unconscionable heretics who place more or less reliance upon what is seen through the modern high-power objective, and who still cling to the belief that the image at the back of the combination affords some safe criterion of the structure of the object lying in front of it.

* * * * * * *

We are all familiar with the striking experiments devised by Prof. Abbe to prove that the so-called diffraction spectra are necessary to the formation of an image, and that their inclusion or exclusion by means of stops at the back of the objective determines the form of the image.

(Diagrams of these appearances thrown upon the screen. See Carpenter, 7th Edn., pp. 67, 68, 69.)

Now all this is very interesting and, in a way, instructive; but are we not too much disposed to jump to the conclusion that we have here proof that all images seen through our high-power lenses are illusory? Let me ask when do such conditions occur in actual work? In our usual investigations we never employ any such stops as you have just seen figured. We do, however, use objectives in which varying proportions of the back lens are covered with image-forming light,—in which, therefore, we have conditions nearly equivalent to using stops with single central openings of different diameters. If no glass can give a correct picture of any element less than the $\frac{1}{2500}$ of an inch in diameter, it is difficult to see what interest attaches to the effect of more or less aperture in high-power objectives except from the side of mere physics, since one false image is no better than any other false one, for purposes of morphological investigation. If, however, every increase of angle is a distinct gain, as we are taught to believe,—if every step towards the attainment of the maximum aperture is a step towards absolute truthfulness in the image,—it would seem as if a progressive reduction of opening should result in wider and wider divergence from faithfulness in the image. But experience does not confirm this inference, for, having once secured resolution of a lined object with a well-corrected wide-angled lens, we may stop it down to a very small fraction of its original aperture without at all falsifying the image. As we diminish the back opening of the objective we continue to see exactly the same parallel lines as long as we can see any distinct image whatever. In illustration of this fact I show a set of photographs of the Abbe diffraction plate, made by Mr. T. F. Smith. They were taken by an apochromatic of 1.40 N.A., and begin with a picture made when as nearly as possible the full aperture of the objective was utilized. Then they show successively the effect of using a stop with a $\frac{1}{12}''$, a $\frac{1}{20}''$ and a $\frac{1}{82}''$ opening, and you will observe that they confirm the statement I have just made, and seem to prove that, under ordinary conditions and within the limits of their resolving powers, our objectives do not play tricks with the forms of objects.

It is because such demonstrations as this tend to increase our faith in the general trustworthiness of our lenses that biologists continue to pursue their investigations by their aid, and to eagerly seek after every new development of the optician's art. It is not because they believe that any existing objective is capable of revealing the very ultimate structure of an object, but because they have, notwithstanding the discouraging doctrines of the theorists, a lingering belief that the revelations of our instruments are honest as far as they go.

If a narrow-angled lens produces a truthful image of a coarse object, may not a glass of a larger angle present a correct representation of the somewhat finer parts, and a really wide-angled objective give us an accurate reproduction of very minute details? Admitting that such may be the case does not preclude a belief in structure still invisible. Nor does it necessitate the belief that every appearance we now perceive is within the realm of truthfulness. While encouraging a general confidence in what we see distinctly, it still leaves room for question and debate as to the meaning of things which we merely glimpse or only half see.

* * * * * * *

I now throw on the screen some of Mr. Smith's photographs of diatom valves, showing the fibrillar structure discovered by him. Many of these are new, but some of them I exhibited in this place four years ago, in illustration of a paper which I then read on his behalf. After the first interest excited by his discovery, the subject does not appear to have received any attention whatever in this country. And yet, whether the appearances so clearly photographed by Mr. Smith are geometrical reproductions of an actual structure or not, their production in the microscope is a fact of importance, and a new fact for which I should suppose it was worth while to account. I, therefore, introduce these pictures now, not so much because of their morphological significance as because of their bearing upon the question of the value of aperture and the criterion of the microscope's truthfulness.

Who, in looking, for example, at the photomicrogaph marked by him No. 10a or No. 19 can, without a positive effort of mind, bring himself to doubt that it is a faithful representation of an existing structure. And how much less easy is it to doubt, when one has made a direct comparison between the original image seen in the microscope and an image of some positively known structure seen through the same lens and under the same conditions of illumination. Suppose, for instance, you place upon the stage one of Webb's specimens of fine diamond writing,—say, the Lord's prayer done in the $\frac{1}{50000}$ of a square inch,—and finding this, as you must believe, truly represented to the eye, you merely substitute for it a valve of Pleurosigma formosum, and find upon it Mr. Smith's fibrillar layer, how are you going to persuade yourself that while the former is seen as it is, the objective must inevitably "fail to reveal to us the real structure" of the latter.

When these photographs were first exhibited before this Society, it was suggested on the one hand that the appearance of fibrils was an effect of oblique illumination and, on the other, that they could not be a real structure because they were seen only upon dry specimens illuminated by means of a dry condenser of N. A. 1, with which it was supposed to be impossible to project through the object and the cover-glass a cone of light having an angle greater than "the critical,"—*i. e.*, 82°,—in consequence of which it was assumed that the objective was practically reduced to this aperture, and could not reveal more than would be shown by any other glass of the same angle. It was held that, in order to establish the correspondence of the image with a veritable structure, the same appearance should be obtained from a specimen in balsam or other medium and under conditions favorable to the utilization of the full aperture of the objective.

Regarding the first point, I can testify from personal observation of Mr. Smith's methods and from a repetition of them with my own apparatus, that the appearances presented in the photographs are obtained with illumination as nearly central as it can be made, although, of course, I am aware that, even when the condenser is carefully centred, the result of the use of a very broad cone of light, such as Mr. Smith employs, may be the introduction of more or less oblique illumination, particularly if the object is not exactly at the focus of the condenser, which seems to be necessarily the case when the condenser really has an aperture close to 180° in air and is worked through a thick glass slip. I have found, however, that the condenser may be stopped down almost indefinitely, by closing the iris diaphragm, without altering the general appearance of the fibrils, and that no such change is produced by shifting the light from the centre to the side as would occur if the image were a mere "ghost."

As to the criticism that the value of a large aperture in the objective is neutralized by its use upon a dry object, I think that, if we are warranted in considering the specimens photographed by Mr. Smith as really "dry," the answer is to be found in the principle expounded on pp. 58 and 59 of the last edition of Carpenter, where it is shown that under the conditions we are considering the objective works as a dry lens of 180° theoretical aperture, and is consequently capable of receiving the light from a condenser of the same angle. It seems to be the case, however, that thus far these fibrils have been seen only upon valves which are in close contact with the cover, to which they have been attached by heat, and it is therefore probable that the surface under observation is not in air at all, but is rather imbedded in the glass. If so, the fibrillar layer is practically mounted in a medium having a refractive index of 1.52, and we have in reality a perfect continuity of homogenous immersion. Mr. Smith, as I understand it, entertains the idea that the fibrils are obliterated in balsam by reason of the approximation of their index of refraction to that of the mounting medium, but if this were the true explanation they should be invisible when imbedded in glass as I have imagined,—crown glass and balsam having substantially the same index. On Mr. Smith's theory, too, the fibrils must have a higher index than that of the silex of the body of the diatom, which is only 1.43. On the contrary, it seems to me more probable that the fibrils are less silicious than the rest of the valve and have a lower index of refraction. But, assuming that they are of the same density as the main part of the valve, their visibility when imbedded in the glass might be accounted for by the difference between the index of crown glass (1.52) and that of silex (1.43). In that case, however, they ought to be visible in any other medium having a refractive index of 1.52 or more. But independently of the considerations already named, it has occurred to me that possibly the mere process of burning the valves may work some physical change which brings the fibrillar structure into bold relief, and it would be a test of this hypothesis, as well as of the others referred to, if valves upon which the fibrils have been seen could be removed from the cover-glass and mounted in balsam and other media, and if at the same time other specimens were subjected to the burning process upon platinum and then so mounted, and if still others cleaned in the usual manner, but not burnt, were mounted in media having indices not less than that of crown glass. A comparison of preparations made by these several methods ought to settle the question as to why the fibrils are observable only on so-called dry specimens attached to the cover-glass by burning. Apropos of the suggestion I have made above, as to the effect of heat, Mr. Smith has expressed the belief that the separation of the layers, and their consequent visibility, is due mostly to disintegration of the structure some time after the diatoms have been mounted, and he thinks it is easy to see how this can happen in a dry mount and not in a medium which becomes solid.

The ability of an objective to separate superimposed structures is a matter to which Mr. Smith very properly attaches much importance, and the only doubt about his position is as to whether he does not regard this separating power as too exclusively a correlative of numerical aperture. We are, of course, all familiar with the fact that the microscope magnifies not only the superficial area of an object, but also its thickness,—its depth dimension as well as its length and breadth. In fact, the capacity of the instrument is much greater in this direction than in the direction of the two dimensions usually taken as the measure of its power. We must not, however, confuse this with depth of vision, or penetration, to which it is in fact diametrically opposed. In the proportion in which we magnify the superficial diameter of an object, the objective includes less of it in the field of view. So, the more we magnify the depth dimension, the less of the object's thickness are we able to see at one focus. For this reason the objective becomes what has been aptly called "an optical microtome," and this microtome cuts thinner and thinner sections as the magnifying power of the objective increases. But it also separates layers which are closer and closer together as the angle of aperture widens. We need to remember, however, that this power of differentiation is as the square of the lineal magnification on the surface, while it is only in direct proportion to the angle of aperture. It is, therefore, vastly more dependent upon power than it is upon aperture.

Mr. Smith has provided us with some interesting photographs (which I now exhibit) showing several diatom valves, first with an old-time water-immersion $\frac{1}{12}$ (the aperture of which he has, however, unfortunately omitted to give us) and then with a recent oil-immersion apochromotic $\frac{1}{12}$ of presumably N. A. 1.40, and the contrast is certainly very striking and wholly in favor of the wider-angled glass. Nevertheless it does not appear to me that we are forced to the conclusion that the improvement in the image is due wholly to the increased aperture of the lens. We must not overlook the fact that the apochromatic system permits of a perfection of correction never reached in any other form of lens, and we must not omit to give this matter its due credit for the clearer definition of the object, and even for the disclosure of details not before perceived. In some of these photographs I confess the superiority of those taken with the apochromatic seems to me due more to the elimination of spherical and chromatic aberrations than to the mere increase in numerical aperture.

At any rate, in comparing lenses with reference to their ability to determine minute structures we ought to take into account three factors, namely, power, aperture and corrections. Neither one of these will account for the result. Aperture is an addition to power, but neither is useful without delicate and accurate corrections. The lenses made before the introduction of the homogeneous immersion and apochromatic principles had ample power, but we were all puzzled to make out why it availed so little. The one-fiftieths of that day were not as serviceable as one-sixths, or even some one-quarters, of the present time,—partly because they were deficient in aperture, but still more because of their confusing and baffling aberrations. Mr. Smith's photographs show that with the Powell & Lealand water-immersion lenses of twelve or fifteen years ago it was not impossible to separate thin layers so much as it was to get a clear image of details in the plane where the objectives worked best. It was not because they had too much penetration, but because while they were weak on the side of resolution, due to lack of angle, they were particularly faulty in the matter of definition, because of their want of correction. I certainly do not mean to say that the production of wider apertures has not added to our ability to see new details. I am merely emphasizing the fact that the invention of the apochromatic principle has made such corrections possible that we are now able to utilize both powers and apertures which were previously of no advantage. At the same time it is worth while to insist upon the fact that Mr. Smith's fibrils are by no means beyond the reach of comparatively low powers and narrow angles, as far as their dimensions are concerned. In fact they are of such a size as to be easily seen by means, not only of simple achromatics of fifteen or twenty years ago, but also of recent one-fifths and one-quarters of numerical apertures much less than 1.0, provided the fibrils are separated from the valve and lie where they can be observed without confusion with any underlying structure. It is when the fibrillar layer is *in situ* that the superiority of the widest-angled lenses becomes evident, for it is then that extreme shallowness and delicacy of focus become effective.

Every increase in numerical aperture will, in my opinion, disclose to us truthful images of structures finer than any pictured to the eye through smaller apertures, provided increase of power accompanies increase of aperture and perfection of correction goes along with both. There is plainly a correlation between the angle of aperture of the objective and the angle of diffraction of the object. Supposing, for illustration, that lines lying within the $\frac{1}{50000}$ of an inch of one another, in air, disperse ordinary white light to a maximum of 62°, and that lines lying within $\frac{1}{100000}$ of an inch of one another similarly disperse light to a maximum of 147°, then an objective having an air angle of 62° (N. A. 0.52) will give a truthful image of the former, but not of any finer lines, while a lens having an air angle of 147° (N. A. 1.04) will correctly represent the latter as well as lines intermediate to these and the others, or coarser still. If, therefore, we had under the microscope a structure composed of elements, part of which were $\frac{1}{50000}$ of an inch in diameter and part $\frac{1}{100000}$ of an inch in diameter, a lens of N. A. 0.52 would reveal the former, and not the latter, but would be absolutely truthful up to the limit named. On the other hand, the lens of N.A. 1.04 would correctly image the finer as well as the coarser parts of the structure up to diameters of $\frac{1}{100000}$ of an inch, while leaving us totally in the dark as to what elements of structure might exist beyond this maximum of its resolving power. It therefore seems to me that Mr. Nelson was in error when he said: "The logical conclusion, granting the Abbe theory to be correct, is that all microscopic diffraction images are false."

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The fact appears to be that the best wide-angled oil immersion and apochromatic objectives accomplish better results even in fields where lower-powered and smaller-angled glasses have hitherto been supposed to be all sufficient. In the formation of what have been considered purely dioptric images they are not less satisfactory than in the disclosure of strictly diffractive effects. Except for use with the Wenham binocular, with which a narrow angle is a *sine qua non*, they seem, in short, to cover the whole ground of microscopical research better than any other existing lenses, and their invention was therefore not merely the addition of a new variety of objective to the general class, but rather a distinct advance in the evolution of the class itself.

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It is, of course, necessary in estimating the performance of an objective to take into account the character of its illumination, and we cannot consistently consider the refinements of optical science and art which have been devoted to the lenses above the stage without also devoting attention to the improvements which have been made in and the ingenuity which has of late been expended upon the sub-stage condenser. Space will not, however, permit my dealing with this subject in detail. Still it seems necessary to remark that the main question now open for discussion with regard to condensers is whether they should transmit a narrow or a broad cone of light and whether the aperture of the condenser should approximate to or match that of the objective. Mr. Nelson has been the leading advocate of the wide-angled condenser and long ago announced the theory that if the angle of the illuminating cone equals that of the objective the image will be a true one, and I think it is mainly to the weight of his authority that we must attribute the demand for apochromatic condensers running to 1.40 numerical aperture and above. But Mr. Nelson also at one time advocated oblique illumination in preference to central, and Prof. Abbe has since condemned both this and the broad illuminating cone as inconsistent with the diffraction theory. If, as the diffraction theory assumes, image-forming rays are given off by very minute objects at all angles up to 180°, without regard to the source of illumination, it is not easy to see how in their case a wide angle in the condenser can favorably affect the result, except in the matter of a greater *quantity* of light. Although Dr. Dallinger, in the last edition of Carpenter, quotes Prof. Abbe's opinion against the wide-angled condenser, apparently with his own endorsement, he subsequently declares himself in favor of the theory that for "ideal" illumination with transmitted light it is essential that the illuminating axial cone should be approximately equal to the aperture of the objective used. He nevertheless admits that under such conditions of illumination the objective "breaks down," and that in actual practice we must be content to sacrifice the ideal, and, to get the best results, must make use of a cone of light only sufficient to fill three-quarters of the back lens of the objective. With condensers, as with objectives, effective aperture is much less than the theoretical, and this fact suggests the query: Why should we go on preaching an "ideal" that is not attainable in practice nor confirmed by experiment?

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PROCEEDINGS.

MEETING OF MARCH 1ST, 1895.

The Vice-President, Dr. Frank D. Skeel, in the chair.

Twenty-seven persons present.

OBJECTS EXHIBITED.

1. Sections of egg of the frog: by G. W. KOSMAK.
2. The same, in advanced development: by G. W. KOSMAK.
3. Transverse section of the skin of the lizard, *Anolis*, showing the layers and pigment cells: by L. RIEDERER.
4. Various insects in gum copal: by GEORGE E. ASHBY.
5. Specimens of gum copal to show varying surfaces: by GEORGE E. ASHBY.
6. Various insects in amber: by FREDERICK KATO.
7. Insects in gum copal: by FREDERICK KATO.
8. Hemipterous larva in amber: by JAMES WALKER.
9. Various insects in amber and copal: by JAMES WALKER.
10. About 100 specimens of insects of different orders in copal and amber: by DR. DANIEL S. MARTIN.
11. Ants in amber: by FRANK D. SKEEL.
12. A large, perfect butterfly, spreading two and one-quarter inches, in amber: by FRANK D. SKEEL.
13. Various insects in amber: by CHARLES S. SHULTZ.
14. Minute fly in amber: by F. W. LEGGETT.
15. Various insects in amber: by F. W. LEGGETT.

The session was largely devoted to the exhibition and discussion of insect inclusions in fossil gums, of which there were displayed about 177 specimens. Prof. Daniel S. Martin, Ph.D., exhibited about 100 specimens from his large collection, answered many questions of members and gave valuable information on the subject. He referred to the nature of the deposits of the Zanzibar gum copal, this having its origin from the tree, *Trachilobium mozambiqueense*, the fossil gum belonging to the quarternary; to the difference between this and amber, found mainly on the north coast of Germany, having its origin in the resin of conifers, and belonging to the early tertiary; to the occurrence of fossil gums in the State of New-Jersey (Keyport and some other localities), found with lignite, of greater hardness than amber, and belonging to the cretaceous; and to the arrested decomposition of the insects enclosed in these fossil gums, instancing his possession of two specimens of large termites in African copal—one of these specimens being accidentally broken, the fracture passing directly through the enclosed insect, and a strong, unpleasant odor being immediately emitted.

Mr. Ashby mentioned several of his interesting exhibits: a dense layer of ants; a spider in close proximity to a fly, giving unmistakable evidence of the chase interrupted by the death of both parties; the streaming of scales from the wings of a struggling moth; a worker termite with a large movable bubble enclosed in liquid in the abdomen; and a curious minute hymenopterous insect, with all four wings reduced to mere clubs, each wing being furnished with large fringing bristles on both anterior and posterior margins.

Mr. Walker referred to his exhibit of a minute but remarkable insect in amber, it evidently being a hemipterous larva, with a stout proboscis passing from the head directly under the abdomen, and projecting about one-quarter of the length of the entire insect beyond the posterior region.

MEETING OF MARCH 15TH, 1895.

The President, Dr. E. G. Love, in the chair.

Twenty-two persons present.

Dr. Max Myer was elected a resident member of the Society.

The Corresponding Secretary read a communication from Dr. Alfred C. Stokes, corresponding member of the Society, entitled "An undescribed species of *Vasciola* with an interesting habit." The thanks of the Society were tendered Dr. Stokes for this communication, and it is published in this volume of the JOURNAL, p. 47.

Dr. Frank D. Skeel read a paper, entitied "Notes on the

Development of the Modern Microscope." The paper was illustrated by many lantern projections, and was discussed by the President, Mr. Riederer, Rev. Mr. Haas and Dr. T. O. Summers.

MEETING OF APRIL 5TH, 1895.

The President, Dr. Edw. G. Love, in the chair.

Twenty persons present.

Mr. William B. Tuthill was elected a resident member of the Society.

The Corresponding Secretary read a communication from Mr. William A. Terry, of Bristol, Conn., entitled "A new Diatom from the California fossil deposits." This communication is published in this volume of the JOURNAL, p. 52. In this connection Mr. Terry donated to the cabinet of the Society twelve slides of diatoms, one slide exhibiting the new diatom referred to in the communication, *Brunia Californica* Terry; one containing the forms of the Floating Fossil of Santa Monica ; one containing the forms from Redondo Beach; and nine slides of Connecticut Shore diatoms.

The thanks of the Society were tendered Mr. Terry for this communication and for the donation of these slides.

OBJECTS EXHIBITED.

1. Sagittal sections of the upper jaw of the embryo of *Anolis principalis*, showing the præmaxillary tooth : by L. RIEDERER.

2. Sagittal sections of the lower jaw of the same, showing embryo teeth *in situ :* by L. RIEDERER.

3. Four photomicrographs of these sections: by EDW. G. LOVE.

4. Minerals from Bergen Hill, N. J.—Heulandite, Datolite, Natrolite, Laumontite: by FREDERICK KATO.

5. The diatom, *Cocconeis vitrea* J. Brun, from Santa Monica material: by HENRY C. BENNETT.

6. Unknown parasite, found burrowing near the hinge in the inner surface of the shell of a living oyster: by F. W. LEGGETT.

7. The shell of the oyster, with the burrow from which the parasite was extracted: by F. W. Leggett.

8. The diatom, *Brunia Californica* Terry, from the Alhambra deposit, California, prepared by William A. Terry: by J. L. Zabriskie.

Mr. Riederer explained that his sections were from an embryo of *Anolis*, extracted from the egg about one week before the natural time of emergence. The upper jaw shows the præmaxillary tooth projecting in a nearly straight line forwards from the centre of the extremity of the jaw, this tooth, which is soon lost, being employed by the embryo for splitting the egg shell. This subject was discussed by Pres. Love and Mr. G. W. Kosmak.

Mr. Kato stated the nature of his mineral exhibits; their locality—the cut of the Pennsylvania Railroad in Bergen Hill, N. J.; and the manner of mounting them in the regulation Rakestraw boxes. A discussion by Pres. Love and Mr. James Walker followed.

Mr. Henry C. Bennett explained his exhibit as follows:

"*Cocconeis vitrea* J. Brun. I found this rare fossil diatom on a slide which I mounted in 1890 from St. Monica material, and which, so far as I am aware, has not been heretofore reported as found in that deposit. It was, however, illustrated and described by J. Brun in a work entitled, 'New Species of Diatoms, marine, fossil, and pelagic,' published in Geneva and Basel, Switzerland, in 1891, as found very rare in Yedo and Szakal.

"The following is the description: 'Valves eliptical, flat and close together. Length, 0.06 to 0.07 m m. Width, 0.04 to 0.05 m m. Superior valve has interrupted, punctate, embossed, delicate striæ toward the border, and forming two lines in the direction of the median region, slightly curved and moniliform. Marginal zone always finely striated. Striæ of the poles parallel with raphe. Inferior valve with more delicate striæ dividing toward the border. Raphe and nodules enveloped in a large hyaline zone. Silica thin and brittle.'

"The superior valve of this diatom is here shown under a $\frac{1}{10}$ homogeneous immersion objective. 1.38 N. A. × 900."

Mr. Leggett explained that the creature exhibited by him was taken from the inner surface of the shell of a living oyster, which seemed to be in good condition and which was certainly of good flavor. The parasite is a thin, disc-like creature, about one-half inch in diameter, and was snugly ensconced in a cavity just adapted to its own size, the cavity having blackened surfaces, and appearing to be eroded deeply in the white inner substance of the oyster shell near the hinge.

ANNUAL EXHIBITION, APRIL 9TH, 1895.

The Sixteenth Annual Exhibition of the Society was held at the American Museum of Natural History, Central Park, New-York City, on the evening of April 9th, 1895.

Objects and apparatus, as noted in the programme below, were displayed in the halls on the second floor of the Museum. Two lectures, both illustrated with projections by the superior apparatus of the Museum, were delivered in the main lecture room: at 8 o'clock by Dr. Frank D. Skeel on "The Microscope—its Construction and History," and at 9 o'clock by Prof. Albert S. Bickmore on "Recent Advances in Visual Instruction." It was estimated that about two thousand persons were present at the exhibition.

EXHIBITS.

1. A collection of apparatus illustrating the history and evolution of the microscope.

a. Part of rude microscope, on wood column. Probably German. Date unknown.

b. A rude instrument, with leather-covered tube, wooden eye-piece, brass support and stage, wooden base, and primitive fine adjustment. Date and origin unknown.

c. Culpepper Microscope, with rack and pinion movement, in pyramidal case, with accessories. About 1738–40. A second form, without accessories. Same date. A third form, with sliding movement only.

d. Cuff Microscope, with rack, pinion and accessories. About 1744–45.

e. Wilson's Hand Microscope. Made by Adams, London, with accessories. About 1746. Another form, with brass support, mirror and stage. With accessories.

f. Jones's Improved Compound Microscope. About 1795.

g. Jones's Model, by Chevallier. About 1795.

h. Small microscope, by Cary. Attached to cover of case. About 1817.

i. French microscope, on two pillars, attached to case, bull's-eye condenser on tube, rack and pinion to stage. Date unknown, but quite modern.

Exhibits a–i, by CHARLES F. COX:

2. *a*. Microscope, by Jones and Son. Latter part of eighteenth century.

b. Microscope, presented by Louis XV. to his daughter: by J. A. GRENZIG.

3. A curious microscope, called "The Traditional," 1776: by MESSRS. GALL and LEMBKE.

4. Microscope of the last century, made by George Stirrop: by DR. CHARLES E. WEST.

5. *a*. Old English microscope of the last century.

b. A form of stand recommended by the Royal Microscopical Society of London. 1866.

c. Microscope made by Grunow, New York, with substage condenser and iris diaphragm. 1872.

d. Stand of Powell and Lealand, with all accessories; *e*. Binocular microscope of R. and J. Beck, London: by DR. WILLIAM STRATFORD.

6 Microscope, by Carl Zeiss, Jena, Germany, with latest form of mechanical stage: by MESSRS. EIMER and AMEND.

7. Bausch and Lomb's "Professional Microscope": by MESSRS. BAUSCH and LOMB.

8. Stand made by E. Leitz, Wetzlar,.Germany: by WILLIAM KRAFT.

9. "Congress Stands," of the W. H. Bulloch type: by E. B. MEYROWITZ.

10. *a*. Section of meteorite, Brentham Co., Kansas.

b. Antique glass from ruins of Tyre: by GEORGE F. KUNZ.

11. Chalcedony pseudomorph after pectolite: by JAMES C. GREGORY.

12. Mosquito in amber: by F. W. LEGGETT.

13. Red garnet, Almandite, trapezohedral crystals: by FREDERICK KATO.

14. Pond life. *Daphnia:* by LOUIS W. FROELICK.

15. Kidney of snail: by W. E. DAMON.

16. Hair from common mouse, *Mus musculus:* by WALTER H. MEAD.

17. Prehnite, Paterson, N. J.: by JOHN W. FRECKLETON.

18. Sections: *a.* Root of Ipecac; *b.* Root of Sarsaparilla; *c.* Tuber of Aconite; *d.* Bark of *Cascara sagrada* (true); *e.* Bark of *Cascara sagrada* (false); *f.* Rhizome of Calamus; *g.* Leaf of Digitalis; *h.* Radix of *Menispermum:* by members of N. Y. COLLEGE OF PHARMACY.

19. *a.* Ganglion cells, human spinal cord; *b.* Ganglion cells, human cerebrum: by DR. SMITH ELY JELLIFFE.

20. *Polynema ovularum:* by THOMAS CRAIG.

21. *a.* Sting and poison glands of Honey Bee; *b.* Scales of Morpho Butterfly: by R. L. DITMARS.

22. Skin of Holothurian, *Synapta inhœrens:* by E. GERBER.

23. *a.* Scales of Bird-wing Butterfly, *Ornithoptera priamus.*
b. Case of specimens of *Ornithoptera:* by WILLIAM BEUTENMULLER.

24. Fish-hatching, various stages: by DOUGLAS W. CAIRNS.

25. Crystals by polarized light: by BAYARD S. CAIRNS.

26. Antennæ of various insects: by HERMANN A. LOOS.

27. *Phylloxera vastatrix:* by WALTER S. CAMERON.

28. Odontophore of mollusk, *Sycotypus canaliculatus:* by JAMES H. TUTTLE.

29. Diatom Type Plate: by HERBERT B. BALDWIN.

30. Musical apparatus of *Cicada septendecim*: by EDW. G. LOVE.

31. *a.* Circulation of blood in tail of tadpole.
b. Movement of protoplasm in cells of *Vallisneria spiralis:* by F. W. DEVOE.

32. Series of embryos of the Alligator and the Chick.
a. Alligator embryo of four days.

b. Chick embryo of four days.

c. and *d.* Older embryos of the same.

e. Alligator embryo several weeks old.

f. Section through base of head of Alligator embryo: by DR. S. F. CLARK.

33. *a.* Karyokinetic figure in male genital cell of the Lobster.

b. Type of invertebrate eye, Scallop, *Pecten:* by A. L. KEAN.

34. The soldier of one of our common Ants, *Pheidole pennsylvanica* Rog.: by J. L. ZABRISKIE.

35. *a.* *Hydra* with attached young.

b. *Salvinia natans:* by O. H. WILSON.

36. Section of ovary of Poppy: by GEORGE H. BLAKE.

37. *a.* Bladder of *Utricularia* with captured crustacean.

b. A Spider in fossil gum copal: by GEORGE E. ASHBY.

38. *a.* Hairs of Caterpillar.

b. Sea sand from Bermuda.

c. Seeds of *Gerardia.*

d. Arranged Diatoms, opaque.

e. Arranged Diatoms, transparent.

f. Mineral section, cuprite: by H. FINCKE.

39. *a.* Ammonia, primate crystals.

b. Chrysalis of Gnat.

c. Marine crustacean, *Caprella:* by E. B. MEYROWITZ.

40. Fibrolite, found in New-York City: by JOHN LAMONT.

41. Wavellite, from Steamboat, Penn.: by A. H. EHRMAN.

42. Laumontite, from Snake Hill, N. J.: by WALLACE GOOLD LEVISON.

43. Spinnerets of a Spider: by H. S. WOODMAN.

44. *a.* Arranged Diatoms.

b. Fern leaf gold crystals.

c. Sting of Honey-bee.

d. Tongue of Blow-fly.

e. Saws of Rose Saw-fly.

f. Eye of Fly: by G. S. WOOLMAN.

45. *a.* *Trichina spiralis.*

b. Proboscis of Butterfly.

c. Foot of Spider: by WILLIAM KRAFTS.

46. A projection microscope in orperation: by J. A. COLT.

47. Pond life: by W. J. LLOYD.

48. Crystals. Asparagine: by ANTHONY WOODWARD.

49. Crystals. Chlorate of potash: by J. B. SNIFFIN.

50. Eye of House-fly: by ALFRED BEUTENMULLER.

51. Crystals. Sulphate of magnesia combined with sulphate of copper: by DR. J. W. METCALF.

52. Section of seeds of Hemlock: by W. F. PROSCHWITZKY.

53. Movement of protoplasm in cell of *Nitella:* by JOHN McCALLUM.

54. Segmenting eggs of *Amphioxus lanceolatus:* by WILLIAM LOWEY.

55. Young clams. Polarized: by H. H. WOTHERSPOON, JR.

56. *a.* Foot of embryo of Cat.
    b. Section of jaw of embryo of Pig.
    c. Section of embryo of Shark.
    d. Section of young Star-fish.
    e. Planaria, living and in preparations: by HENRY E. CRAMPTON, JR.

57. Skin of Eel, polarized: by HENRY C. BENNETT.

58. Hydroid colony, *Endendrium:* by F. COLLINGWOOD.

59. Circulation of blood. Foot of Frog: by JOSEPH C. THOMPSON.

60. Various stages in the incubation of the hen's egg: by GEORGE W. KOSMAK.

61. *a.* Section of scalp of Monkey.
    b. Section of stem of Bamboo.
    c. *Volrox globator*, living: by CHARLES S. SHULTZ.

62. Section of petiole of white Water Lily: by DR. CARLTON C. CURTIS.

63. Breathing apparatus of *Nerium oleander:* by E. A. ANDERSON.

64. Sphaero-crystals of inulin, from tuber of Sunflower: by CHARLES W. OGDEN, JR.

65. Odoriferous glands of Tomato plant: by I. M. RUBINO.

66. "How the Fern grows": by MISS ANNA A. SCHRYVER.

67. *a.* Crystals of silver.

b. "Rolling stones," polarized.

c. *Eozoon Canadense*, polarized.

d. Inclusion in mica: by MISS AGNES V. LUTHER.

68. *a.* Compound eyes and multiple images.

b. Flint sponge, *Astylospongia:* by J. D. HYATT.

69. The common southern Lizard, *Anolis principalis*.

a. Left foot of embryo.

b. Section of skin from neck of adult.

c. Longitudinal section of upper jaw of embryo showing præmaxillary tooth.

d. Transverse section of head of embryo: by LUDWIG RIEDERER.

70. Living Wolffia, the simplest and smallest of flowering plants, from Staten Island, N. Y.: by WILLIAM T. DAVIS.

71. Foraminifera: by CHARLES P. ABBEY.

72. Polycistina, arranged: by G. W. MULLER.

73. Minerals sometimes used as gems, shown with automatic revolving stage and polarized light. And cabinet specimens of the same.

a. Quartz, var. Agate, from Oberstein, Germany.

b. Quartz, Tiger Eye, pseudomorph after Crocidolite.

c. Oligoclase, var. Sunstone, from Norway.

d. Lazurite, Lapis-Lazuli, from Chili.

e. Microcline, var. Amazon-stone, from Virginia.

f. Labradorite, from Labrador coast.

g. Orthoclase, var. Sunstone, from Sussex Co., N. Y.: by JAMES WALKER.

MEETING OF APRIL 19TH, 1895.

The President, Dr. Edw. G. Love, in the chair.

Twenty-five persons present.

On motion the thanks of the Society were tendered to the President and Board of Trustees of the American Museum of Natural History for their kindness in granting the use of the halls of the Museum; to Mr. William Wallace and his attendants for the valuable assistance rendered; and to Prof. Alfred S. Bickmore for the able lecture delivered, all on the occasion of the late Annual Exhibition of the Society.

The President, Dr. Edw. G. Love, addressed the Society on "Micrometers and Methods of their Use." This address was illustrated by ten enlarged drawings explaining the structure and working of micrometers.

OBJECTS EXHIBITED.

1. A Leitz filar micrometer of very fine platinum wire: by CHARLES S. SHULTZ.

2. A celebrated stage micrometer, ruled on speculum metal, by Prof. Rogers: by CHARLES S. SHULTZ.

3. An antique stage micrometer: by F. D. SKEEL.

4. A micrometer by Cuff, 1746–47: by E. G. LOVE.

5. George Jackson's eye-piece micrometer, made fifty years ago: by E. G. LOVE.

6. Zeis eye-piece micrometer: by E. G. LOVE.

7. Abbe camera lucida: by E. G. LOVE.

8. Spores of *Equisetum*, showing hygroscopic movements: by FREDERICK KATO.

9. An unknown insoluble residuum from candy: by F. W. LEGGETT.

10. Connecticut coast diatoms: from Leete's Island, Beauford deposit, Morris Creek, Quinapiac Clay Pits, and Quinapiac East Side Pit. Slides prepared and donated by William A. Terry of Bristol, Conn.

Dr. Skeel, in reply to certain questions, explained the difficulty of fastening spider web cross lines in telescope tubes, and stated that very attenuated platinum wire was sometimes obtained by using fine platinum wire as a core within copper wire, drawing out both metals together through fine dies, and finally removing the copper by means of acids.

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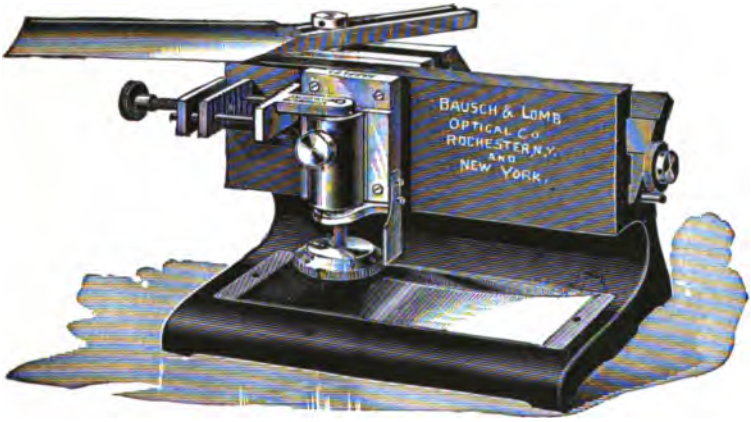

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